Published Monthly. Price, $5.00 per Annum.

THE JOURNAL

OF THE

AMERICAN CHEMICAL SOCIETY,

AND

JOURNAL OF ANALYTICAL AND APPLIED CHEMISTRY.

VOL. XV.—NO. 11.

NOVEMBER, 1893.

[Issued December 13, 1893.]

COMMITTEE ON PAPERS AND PUBLICATIONS:
EDWARD HART, Editor, J. H. LONG, EDGAR F. SMITH.

CONTENTS.

	PAGE.
The Cross-Fertilization of the Sciences. By Robt. B. Warder	601
The Composition of American Cheddar Cheese. By L. L. Van Slyke	605
The Purification of Water, with Special Reference to Boiler Feed Waters and Scale Prevention. By C. A. Doremus	610
Improved Apparatus for the Volumetric Determination of Carbon Dioxide and other Gases. By Charles A. Catlin	614
Are Pentoses Formed by the Assimilation Process? By Dr. G. de Chalmot	618
Improvements in the Manufacture of Sulphuric Acid. By Peter S. Gilchrist	624
The Education of Industrial Chemists. By Henry Pemberton, Jr	627
The Determination of Casein in Cows' Milk. By L. L. Van Slyke	635
Some Points Relating to the Composition of Cows' Milk. By L. L. Van Slyke	645
Improved Ureometer. By Professor J. I. D. Hinds	650
Chemical Considerations on the Pottery Industries of the United States. By Karl Langenbeck. Part I	651
Contributions to the Study of Oil-Cakes used in Feeding. By C. V. Garola	656
Concerning the Method of Determining the Melting Point of Butter. By Adolf Mayer	661
New Books	664

EASTON, PA.:
CHEMICAL PUBLISHING COMPANY.

AGENT FOR GREAT BRITAIN:
WM. F. CLAY, 18 TEVIOT PLACE, EDINBURGH, SCOTLAND.

Entered at the Post Office, Easton, Pa., as Second Class Matter.

OFFICERS OF THE AMERICAN CHEMICAL SOCIETY.

President: H. W. Wiley, Dept. of Agriculture, Washington, D. C.

Vice Presidents: J. H. Appleton, Brown Univ., Providence, R. I.
C. R. Stuntz, Woodward High School, Cinn., O.
P. T. Austen, Brooklyn Poly. Inst., Brooklyn, N. Y.
F. P. Dewey, 621 F st., Washington, D. C.

General Secretary: Albert C. Hale, 551 Putnam ave., Brooklyn, N. Y.

Treasurer: C. F. McKenna, 221 Pearl st., N. Y. City.

Librarian: F. E. Dodge, 248 Eleventh st., Brooklyn, N. Y.

Committee on Papers and Publications: Edward Hart, Editor, Lafayette College, Easton, Pa.; E. F. Smith, Univ. of Penna., Phila., Pa.; J. H. Long, 2421 Dearborn st., Chicago, Ill.

Committee on Nominations to Membership: C. A. Doremus, 59 W. 51st st., N. Y. City; A. A. Breneman, 97 Water st., N. Y.; William McMurtrie, N. Y. Tartar Co., 106 Wall st., N. Y. City.

Finance Committee: A. P. Hallock, 440 First ave., N. Y. City; Durand Woodman, 80 Beaver st., N. Y. City; Frank T. King, 91 Columbia Heights, Brooklyn, N. Y.

Board of Directors. Members ex-officio: H. W. Wiley, Pres., Albert C. Hale, Gen. Sec., C. F. McKenna, Treas., F. E. Dodge, Librarian, Edward Hart, Editor. *Term expires Dec., 1893:* C. A. Doremus, 59 W. 51st st., N. Y. City; P. T. Austen, Brooklyn Poly. Inst., Brooklyn, N. Y.; Durand Woodman, 80 Beaver st., N. Y. City; C. F Chandler, School of Mines, Columbia Coll. N. Y. City. *Term expires Dec. 1894:* A. H. Sabin, Box 85, Long Island City, N. Y.; A. A. Breneman, 97 Water st., N. Y. City; A. R. Leeds, Stevens Institute, Hoboken, N. J.; W. McMurtrie.

Council. Members ex-officio: H. W. Wiley, Pres., Albert C. Hale, Gen. Sec., Edward Hart, Editor. *Term expires Dec. 1893:* J. H. Appleton, Brown University, Providence, R. I.; C. E. Munroe, Columbian University, Washington, D. C.; C. F. Chandler, School of Mines, Columbia College, N. Y.; T. G. Wormley, University of Pennsylvania, Phila., Pa.; C. B. Dudley, Altoona, Pa. *Term expires Dec. 1894:* G. F. Barker, 3909 Locust st., Phila., Pa.; Alfred Springer, 46–50 E. 2d st., Cincinnati, O.; F. W. Clarke, Chief Chemist U. S. Geol. Surv., Washington, D. C. *Term expires Dec. 1895:* G. C. Caldwell, Ithaca, N. Y.; J. W. Mallet, Univ. of Virginia, Charlotteville, Va.; T. H. Norton, Cincinnati Univ., Cincinnati, O.; A. B. Prescott, Univ. of Mich., Ann Arbor, Mich.

Local Sections. Rhode Island Section: J. H. Appleton, Pres. Officer, E. E. Calder, Sec., Board of Trade Building, Providence, R. I. *Cincinnati Section:* Chauncey R. Stuntz, Pres. Officer, W. Simonson, Sec., 9th and Race sts., Cincinnati, O. *New York Section:* P. T. Austen, Pres. Officer, Morris Loeb, Sec., 37 E. 38th st., N. Y. City. *Washington Section:* F. P. Dewey, Pres. Officer, A. C. Peale, Sec., cor. 12th and F sts.

Members wishing extra copies of the Journal may obtain them of F. E. Dodge, Librarian, 248 Eleventh street, Brooklyn, N. Y., at the rate of $3.00 per annum.

VOL. XV. NOVEMBER, 1893. NO. 11.

Issued December, 1893.

THE JOURNAL

OF THE

AMERICAN CHEMICAL SOCIETY.

THE CROSS-FERTILIZATION OF THE SCIENCES.

OPENING ADDRESS FOR THE WORLD'S CONGRESS OF CHEMISTS, SECTION OF PHYSICAL CHEMISTRY.[1]

BY ROBT. B. WARDER, WASHINGTON, D. C.

IT gives me pleasure to take my turn, while introducing the subject of physical chemistry, to welcome our guests from far and near, and to thank you for the interest shown throughout the week.

Science has been defined as *knowledge classified*; and there are philosophers whose special anxiety it is to find pigeon holes duly arranged in rank and file, where the several classes of facts can be stowed away in order like the various genera and species of a fauna or flora. But the boundaries of a science, as of a biological species, can not always be defined. Hybridism in knowledge, as in husbandry, yields offspring of special value. The late Dr. Gray was wont to exhibit the wonderful natural contrivances of the orchids, by which each pistil should not be fertilized by its own pollen, but by that from some other flower. To this habit no doubt is largely due that wonderful development of form and color. The practical stock-raiser or horticulturist, with an ideal sheep, or cotton-plant, or chrysanthemum, in his mind, proceeds to select and unite the parents, combining the several desirable characteristics, so that the product more and more closely approaches his ideal.

So also in the evolution of science, the most striking developments appear in the judicious combination of distinct parents.

[1] Read August 26, 1893.

The laws of planetary motions lay hidden, until mathematical analysis under Kepler and Newton joined hands with the long record of nightly observations. In more recent times a "new astronomy" has arisen, counting its parentage from the old astronomy on one side and from physics on the other. The presidential address on orology, which was read at Madison last week,[1] sought to trace the history of the mountain range, by uniting the studies of mathematical physics with stratigraphical and dynamical geology.

It is especially true in the problems of daily life, that conclusions must be reached, not belonging to any one line of investigation, nor to two, but to nearly the whole range of science. A dairyman, for example, with one hundred acres of ground, wishes to produce as many pounds of butter as possible. Geology may contribute to the interpretation of his soil; biology is directly concerned with his pasture and his herd; chemistry and physics deal with the processes of feeding and manufacture; while the best market for the butter and utilization of by-products must conform to the laws of political economy.

It is needless to multiply such illustrations. The manufacturer and the engineer can never say of any kind of science, "That will be of no use to me." A life-time may be spent luxuriating in the riches of any one science (if one has leisure for such luxury), but the most important and fruitful outcome in our day is usually the product of different sciences.

The fertility of such union is especially noteworthy in chemistry and physics. Look at some examples from the papers just read in this Congress. Professor Prescott, in discussing advances in analysis,[2] reminds us of optical and thermal determinations, and of those based on solubility, capillarity, etc. The chemical world, he says, is alive to the new physical chemistry, and none are more indebted than analysts. The same fact is further illustrated in the distinguishing properties of olive oil as set forth by Professor Rising. The proper adjustment of potential and current is required in electrolytic separations;

[1] By Professor Joseph Le Conte, retiring President of American Association for the Advancement of Science.

[2] *This Journal*, 15, 376–379. See also "Methods of Testing Fats and Oils," by Milliau, *this Journal*, 15, 153–172.

and the speed of chemical action (varying with the temperature) must be responsible for many discrepancies in the estimation of citrate-soluble phosphates.

Passing to organic chemistry, the question introduced by Professor Witt,[1] "Why make so many dye-stuffs?" led us to the absorption (or subtraction) theory of the mixture of pigments, as distinguished from the addition theory, applicable to physical colors. Still more singular is the extension of the theory of solution to cover the nature of dyed wool, silk, or cotton, where the dye must be selected with due regard to its solubility in the fiber to be colored. In this industry, conditions of chemical equilibrium are especially important. Bright colors with a high degree of chemical energy may sell well the first season, but in the end are sure to disappoint all parties concerned.

The scientific and statistical basis for the assessment of farms has been discussed by Professor Thoms.[2] The principles of political economy involved may be referred to those officials who require the farmer to pay more than his share of tax, but the subject of values was seen to be closely linked to both the chemical composition and the physical properties of the soil.

To review yesterday's papers on technological chemistry and to point out all the fruits of cross-fertilization between chemistry and physics, would tax your patience too far. Some of the more striking illustrations are found in the apparatus for rapid removal of latent heat from vapor of nitric acid as described by Dr. Hart;[2] the judicious selection of a solvent for the electrolysis of alumina, and the economical preparation of a disinfecting fluid by electrolysis of sea water[3] as discussed by Professor Langley.[3]

In all the operations and needs of daily life, we find chemical substances adapted to their several purposes in virtue of their physical properties. For many years the discussion of density, solubility, optical, thermal, and electrical properties,

[1] "Artificial Coloring Matters," *this Journal*, 15, 456–463.

[2] Not yet published.

[3] Other industrial applications were presented to the Section of Physical Chemistry in a paper, "On Apparatus for Promoting the Interaction of Liquids and Gases," by Professor George Lunge, *this Journal*, 15, 361–374.

crystalline form, etc., were grouped under the name of chemical physics. A vast store of facts was accumulated, of somewhat empirical character, like a valley of dry bones. A new life has appeared with the recent developments of the doctrine of energy. The old name takes a new form. The old numerical data have been greatly extended with the addition of broad generalizations. Physical chemistry is the order of the day. But what is this physical chemistry? And what is it for?

Nearly twenty years ago, a chemical student in Berlin was using costly organic materials by the hectogram or kilogram to prepare some new compound in quantities barely sufficient for analysis. Looking forward he dreamed of some general laws yet to be discovered by which it might be known whether a given blackboard equation would or would not find its counterpart in the laboratory without the necessity for such expenditure of time and material to prove each point. Are we not to-day somewhat nearer the realization of that dream?

We form a plan and want to know whether it will work. We put it into execution and find it works in part. There are losses, sources of waste, that must be overcome before the process can fulfill our wishes. We now ask, not merely, Will it work? but How far will it work? And this is the very question in its general form which occupied the mind of J. Willard Gibbs about the same time that the student was indulging in his reveries. The result was a paper, "On the Equilibrium of Heterogeneous Substances," a paper bristling with differentials and integrals, with the merit of applying equally to physical and to chemical operations. It presents the fundamental principles of change or non-change in general terms, requiring only the proper application of minor premises to yield the particular facts desired. Experiment is still required to find the minor premise, but rapid progress has been made.

This is abundantly shown by Professor Ostwald's last volume on chemical energy, covering more than 1,100 pages. This distinguished author has very kindly sent us a brief review of the leading principles in the paper next on the program.[1] Sooner or

[1] "On Chemical Energy," *this Journal*, 15, 421–430. The translation was kindly made for the Congress by Mr. Wm. H. Krug.

later this new leaven will doubtless be felt in agriculture, in technology, and in biology. Already we find a special chair of physical chemistry in Cornell University, from which we shall hear further.[1] Other universities may do well to recognize this middle field in fixing the limits of the several professorships. The time is at least ripe for a more general acquaintance with the subject.

THE COMPOSITION OF AMERICAN CHEDDAR CHEESE.[2]

By L. L. VAN SLYKE.

IN the course of a large number of experiments made in the manufacture of cheese at the New York (Geneva) Experiment Station, a careful study was made of the composition of the cheese manufactured. Knowing the composition of the milk and of the resulting cheese, it was possible to trace the influence of the composition of the milk upon the composition of the cheese. The results given are for the green cheese as it came from the press. The composition of the cheese in a cured or marketable condition can be calculated by allowing for a loss of water varying from four to eight per cent. The first thoroughly reliable analyses of American cheese by an American chemist were published by Dr. Caldwell in 1877, but these were not large in number, and the composition of the milk was not given or known.

The points relating to the composition of cheese upon which I desire especially to dwell briefly are the following:

1. Water and solids.
2. Fat.
3. Casein and albumen.
4. Relation of fat to casein in cheese made from normal milk.
5. Relation of fat to casein in cheese made from skimmed milk.
6. Relation of fat to casein in cheese made from milk containing added cream or other fat.

[1] "The Fundaments of Chemical Theory," by Professor J. E. Trevor, *this Journal*, 15, 430–448.

[2] Read before the World's Congress of Chemists, August 24, 1893.

7. Changes in composition taking place during the ripening process.

I.—WATER AND SOLIDS IN CHEESE.

Taking all the cheese made from normal milk during six months the per cent. of water in the green cheese varied from 33.50 to 42.90 and averaged 36.50 per cent. There was a greater variation in water than in any other constituent of the cheese. Our work shows that cheese-makers are far from being able to control the amount of moisture to be retained in cheese. To discuss the question as to how much moisture it is desirable to retain in cheese would take us beyond the limits of this paper. The variation in solids was, of course, the same as that of moisture.

II.—FAT IN CHEESE.

The per cent. of fat varied from 30.84 to 37.24 and averaged 34.33 per cent. This variation in fat was caused quite as much by variation in the water retained as it was by variation in the composition of the milk used.

III.—CASEIN AND ALBUMEN.

The amount of casein and albumen varied from 22.11 to 26.10, and averaged 24.25 per cent. The amount of albumen retained in cheese from milk is very minute and probably does not exceed 0.10 per cent., so that we might justly speak of the nitrogen compounds contained in cheese as casein alone.

IV.—RELATION OF FAT TO CASEIN IN CHEESE MADE FROM NORMAL MILK.

In another paper I have shown that the fat and casein in normal milk bear a fairly definite relation to each other. A similar relation also holds good for cheese made from normal milk. We found that almost without exception cheese made from normal milk contained not less than 1.30 pounds of fat for one pound of casein; the average was 1.42 pounds of fat for one pound of casein, while the ratio does not often drop below 1.35.

V.—RELATION OF FAT TO CASEIN IN CHEESE MADE FROM SKIMMED MILK.

Removal of fat from milk influences the composition of cheese in much the same way that it does that of milk. Skimming milk increases the amount of casein relative to the fat not only

in the milk, but also in the cheese made from such skimmed milk. The greater the amount of fat removed from normal milk, the less will become the amount of fat relative to casein in the resulting skim-milk as well as in the cheese made from such skim-milk. In no case did we find cheese made from skim-milk to contain as much as 1.30 pounds of fat for one pound of casein. The nearest any cheese came to this was one made from milk, from which less than ten per cent. of its fat had been removed, and in this cheese the ratio was 1.27. When milk is skimmed before being made into cheese usually not less than one-fourth or one-third of its fat is removed, because it does not pay to remove less than this. In such cases, the cheese contains about equal parts of fat and casein. I feel quite confident that this relation can be made to serve as a basis for the identification of cheese made from skim-milk, and that, in case of cheese made from the mixed normal milk of herds of cows, there will rarely or never be less than 1.30 pounds of fat for one pound of casein, unless the cheese was made from skimmed milk. A well-known author says that a cheese which contains less than ten per cent. of fat may with propriety be called skim. I should say that any cheese is a skim-cheese if it contains less than 1.30 pounds of fat for one pound of casein even if it contained forty per cent. of fat.

VI.—RELATION OF FAT TO CASEIN IN CHEESE MADE FROM MILK CONTAINING ADDED CREAM OR OTHER FAT.

The effect of adding cream or other fat to normal milk is to make the amount of fat larger relative to the casein, and the same effect is produced in the cheese made from such milk, so that there will be 1.70 or more pounds of fat for one pound of casein.

The statement is commonly made that good whole-milk cheese consists of one-third water, one-third fat, and one-third casein. This certainly is a convenient statement to remember, but for accuracy it can not be commended; for I have never yet in my work met with a sample of normal milk of such composition as would make such cheese as the above three-thirds cheese; Such cheese could be made only from partially skimmed milk, if it could be made at all.

To summarize, we found that the composition of green Cheddar cheese as made in our American cheese factories, averaged during the season as follows in round numbers:

	Per cent.
Water	36.50
Solids	63.50
Fat	34.25
Casein	24.25
Ash, sugar, etc.	5.00

Such cheese would have approximately the following composition when it reached the consumer:

	Per cent.
Water	31.50
Solids	68.50
Fat	37.00
Casein	26.25
Ash, sugar, etc.	5.25

VII.—CHANGES IN COMPOSITION OF CHEESE TAKING PLACE DURING THE RIPENING PROCESS.

Cheeses were made from milk of varying composition and under certain different conditions; they were analyzed when green and again when five months old. They were kept in a room the temperature of which varied from 60°–70° F.

1st.—Loss of Weight.

(a) The total loss of weight varied from 10.65 to 17.20 per cent. and averaged 13.53.

(b) The loss of weight was greatest in the cheese which contained, when green, the largest amount of water of any cheese made from normal milk.

2d.—Loss of Water.

The amount of water lost in five months varied from 8.14 to 14.95 per cent. and averaged 10.60 per cent. This was equivalent to from 20.56 to 34.83 per cent. of the water in the cheese, with an average of 26.58.

3d.—Loss of Solids.

The amount of solids lost varied from 1.57 to 3.90 and averaged 2.88 per cent. of the cheese; this was equivalent to from 2.50 to 6.80 per cent. of the solids in the cheese with an average of 4.82 per cent.

4th.—Loss of Fat.

There was practically no loss of fat.

5th.—Loss of Casein.

In every case there was a loss of casein varying in amount from 0.90 to 2.20 per cent. and averaging 1.48; this was equivalent to from 4 to 7.83 per cent. of the total casein present in the cheese, with an average of 6.15 per cent.

6th.—Changes in the Form of Casein.

(a) In every case the amount of soluble nitrogen compounds increased very much in five months. In the cheese, when green, the amount of nitrogen in the form of soluble compounds varied from 0.10 to 0.26 per cent. of the cheese and averaged 0.16 per cent., which was equivalent to from 3.12 to 7.19 per cent. of the total nitrogen in the cheese, with an average of 4.23 per cent. At the end of five months the amount of nitrogen in the form of soluble compounds varied from 0.98 to 1.70 per cent. of the cheese, with an average of 1.24, which was equivalent to from 28.57 to 47.33 per cent. of the total nitrogen in the cheese, with an average of 35.52 per cent.

(b) The cheese, when green, contained no nitrogen in the form of amide compounds, while at five months there was contained from 0.26 to 0.50 per cent., with an average of 0.39, which was equivalent to from 7.58 to 13.93 per cent. of the total nitrogen in the cheese with an average of 11.66 per cent.

(c) The cheese, when green, contained no nitrogen in the form of ammonium compounds, while at five months there was contained from 0.078 to 0.126 per cent., with an average of 0.103, which was equivalent to from 2.42 to 3.51 per cent. of the total nitrogen in the cheese, with an average of 2.92 per cent.

(d) The cheese, in the manufacture of which the largest amount of rennet was used, contained considerably more of the soluble nitrogen compounds than did any other cheese when five months old. This would indicate that the amount of rennet used had some influence upon the rapidity of ripening.

(e) The cheese made from partially skimmed milk contained the smallest proportion of soluble nitrogen compounds at five months, while the cheese made from milk containing added

cream contained with a single exception the largest proportion of soluble nitrogen compounds. This would indicate that in cheese rich in fat the insoluble casein is converted into soluble forms more rapidly than in case of skim-milk cheese; in other words, cheese rich in fat becomes digestible in ripening more rapidly than skim-milk cheese.

THE PURIFICATION OF WATER, WITH SPECIAL REFERENCE TO BOILER FEED WATERS AND SCALE PREVENTION.[1]

By C. A. Doremus.

PROF. VIVIAN B. LEWES, of the British Royal Naval College, has epitomized in two papers read before the Institution of Naval Architects in 1889 and 1891 a series of the most highly interesting and instructive analyses and experiments on incrustations in marine boilers and their causes to be found in the literature relating to scale formation.[2] A careful study for some years of a great variety of boiler feed waters from all sections of the country has convinced me that many points brought forward by Professor Lewes are so generally applicable that they can not be overlooked by the chemist who attempts to rectify the serious troubles arising from these sources.

The following quotations are typical: "The presence of calcium sulphate exercises a very marked influence upon the condition and physical properties of the incrustation as under the conditions in which it is formed in a boiler it separates in a crystalline form and binds the deposit into a hard mass, an action which is also aided by the presence of magnesium hydrate." When calcium sulphate is deposited from sea water in a boiler it comes down in small crystals containing two molecules of calcium sulphate and one of water; whilst after deposition in the boiler and in contact with the heated plates and tubes, it undergoes a further change of crystalline form, and becomes "anhydrite, which is pure calcium sulphate free from

[1] Read before the World's Congress of Chemists, August 25, 1893.

[2] *Chemical News*, 59, 222, and 63, 191.

water of crystallization, and it is this change in crystalline form which binds deposits containing it into such a hard mass."

In many carbonated waters the calcium carbonate also forms upon the heated surface as a crystalline coating, even though the quantity in solution is trivial. Thus in a Croton water which carries but a grain or two per gallon a scale forms on all heated surfaces, tubes as well as crown sheets, which is distinctly crystalline. The massive concretions often found in feed water heaters are crystalline in structure and firmly adherent to the hot tubes or surfaces. It is very easy to show this by a simple experiment. Place a carbonated lime water in a beaker. Raise it to boiling by steam delivered into it by a glass tube. The latter will become coated with an adherent crystalline layer of calcium carbonate. With gypsum water the incrustation does not form so readily since calcium sulphate is soluble to some extent in boiling water, and thorough precipitation not taking place before 140° to 150° C., a state of affairs reached in practice in boilers, where the calcium sulphate then separates in a crystalline form and attaches itself to the rough heated metal.

In a paper read at the Newport meeting I called attention to the use of sodium fluoride as an agent hitherto overlooked in water purification. Since then I have had opportunities to get the results of its use in several lines of work, but the present paper will be restricted to the service this substance renders in scale prevention. Starting with the idea that is so prevalent, that successful treatment of feed waters should be accomplished by such chemical or mechanical, or combined chemical and mechanical treatment, that the incrusting salts should be removed previous to the water entering the boiler, it was soon seen that this theoretical ideal was not practicable. There are many waters which yield an incrustation, whose proportion of lime and magnesium salts is so small that precipitation can not be effected either by the use of feed water heaters or of chemicals. Yet such waters yield a crystalline scale and often a scale containing magnesium hydrate. Surface condensers are frequently leaky, and many marine boilers starting with good water acquire scale from this cause. Manifestly such waters

can only be treated by chemical means in the course of concentration in the boilers. From these almost soft waters we pass by upward grade to the excessively hard, which can be purified in some measure merely by heating or by chemicals. Since, however, calcium sulphate is not completely precipitated at 100° C., feed water heaters do not remove it thoroughly enough to prevent scale, and where waters have a permanent as well as temporary hardness due to magnesium salts these are not eliminated. When lime, soda ash, or caustic soda, or a combination of any of these is made use of, it is difficult to regulate the amount required to effect so complete a precipitation that no scale will form, and the trouble attendant on this style of purification is so great that in many cases it has been abandoned. Water softened by lime and soda ash or treated by soda ash or caustic, will generally possess an alkaline reaction, and is, for some purposes therefore unserviceable. The chemical treatment frequently causes the lime salts to separate in crystalline form, large masses of great thickness being formed.

In one instance the feed pipe for a battery of boilers, though five inches in diameter, became so incrusted that a one-inch bar could not be thrust through it. The water had been treated with soda ash and afterwards filtered.

At an artificial ice factory using hard well water the sand of the filter became hard as stone from the calcium carbonate which crystallized upon it even after the water had been treated with soda ash and heated to soften it.

The cost of chemical treatment is often a bar to its employment quite aside from the expense of accessory apparatus, as settling tanks, filters, etc., since to be effective at least the theoretical quantity of precipitant must be used, with soda ash two or three times this quantity.

When sodium fluoride is added to water containing even a very moderate proportion of lime or magnesium salts a precipitate forms at once. When added in quantity sufficient to unite with all of the calcium and magnesium to form fluorides of these metals and the water is then boiled down the precipitate retains its amorphous character. Viewed through the microscope, it has always been found powdery and rounded. This circum-

stance together with other considerations has led to the employment of sodium fluoride in the direction of scale prevention, and it is pleasant to be able to record that to-day it is in successful operation in nearly every section of the country.

It is not an uncommon practice abroad[1] to employ sodium carbonate directly in the boiler, transforming the calcium sulphate to carbonate. The conversion not only of the sulphate of calcium but all magnesium salts to pulverulent fluorides therefore seemed possible and has proved practicable. Calcium fluoride has a molecular weight about twenty-five per cent. less than either calcium carbonate or sulphate or an equivalent quantity of phosphate and therefore the precipitate or sludge formed through its use is much more manageable and removable by blowing down the boilers.

At first it was deemed necessary to determine the total calcium and magnesium of the water often to make a sufficiently complete analysis to determine the salts held in solution and to calculate from these data the quantity of sodium fluoride necessary to transform the calcium and magnesium to fluorides.

Carefully made tests have shown, however, that in the greater number of instances a quantity of sodium fluoride one-quarter of this theoretical amount will, if fed continuously, prevent the formation of scale and leave the interior surface of the boiler so smooth that one chief cause of crystals attaching themselves is done away with.

The various types of water from New York to Albany and from there through the salt district to the lakes at Buffalo are now under this treatment with entirely satisfactory results. The employment of so small an amount of the chemical naturally reduces the cost of purification, while the ease of handling pleases the engineer.

More than once it has happened that the boilers were heavily incrusted when the use of the fluoride was begun. The old scale was found to loosen rapidly, falling off in some cases by the bucket full. In others it was rotted and softened so that on the first cleaning it was easily scraped off.

A specimen of highly silicated scale is presented to show how

[1] L. Vignon, *Bull. Soc. Chim.*, III, 2. p. 596.

a chemical transformation with the formation of fluoride has resulted from the continued action of small quantities of sodium fluoride added to the feed water. When once thoroughly cleaned to the metal new scale does not form in such instances.

Live steam is so frequently used now in our large manufacturing establishments for cooking, boiling, etc., and so much condensed steam is used to furnish distilled water, especially in artificial ice manufacture, that a method of treating boiler water in such a way as to furnish pure untainted steam is exceedingly desirable. Since sodium fluoride completes its work without rendering the water alkaline the steam from water thus treated has proved most excellent for such purposes.

It is beyond the province of this article to enter more fully into these details.

IMPROVED APPARATUS FOR THE VOLUMETRIC DETERMINATION OF CARBON DIOXIDE AND OTHER GASES.[1]

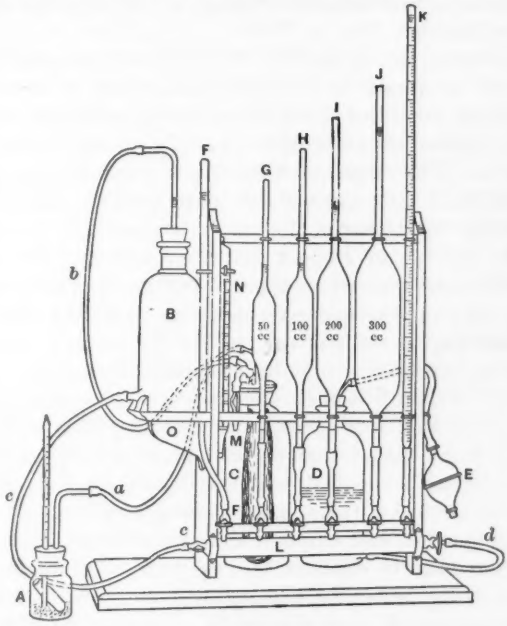
By Charles A. Catlin.

FOR the determination of small quantities of carbon dioxide in readily decomposed carbonates, the process and apparatus devised by Dr. Scheibler presents a most convenient and rapid method; but the inability to thus measure large quantities of gas has restricted its employment for the most part to determination of carbonate in bone-char. To extend the field of volumetric carbon dioxide determination I have devised the following described apparatus, retaining, as far as possible, the essential features of the Scheibler.

Referring to the cut: A, C, and D are essentially the same as in the Scheibler apparatus, A, being the decomposing bottle in which the portion of the sample to be operated upon, is placed, with its enclosed tube for the decomposing acid or other solution, with the further addition however, of a thermometer, inserted through the rubber stopper—a most important feature when the decomposition results in wide variations of temperature; C, the bottle containing the rubber gas balloon connected

[1] Described at June, 1893, meeting of the Rhode Island Section of the American Chemical Society.

with A, and D the water reservoir with compressing bulb E, exactly as in the Scheibler device. In the Scheibler apparatus however, the volume of the gas evolved is directly determined by the displacement of water in a graduated tube, the capacity of which is, and must be, quite limited.



In my apparatus I have replaced this graduated tube by the bottle B, connected by the tube *b* with the space around the rubber bag in the bottle C, and by the tube *c* from its bottom, through the stopcock, with the tube L, which tube L connects, through another stopcock at its opposite end, with the reservoir D, by means of the tube *d*. This tube L, which may be constructed of brass if more convenient, is fixed horizontally upon the standards, as shown in the cut, and has affixed along its upper portion, a series of stopcocks, one of which connects with the tube F, and each of the others individually, with the pi-

pettes G, H, I, and J,* and the burette K. These pipettes may be respectively (using a fifty cc. burette for K) 50, 100, 200, and 400 cc. capacity, graduated as to contents, between marks on the stem and delivery tube, in each case. The tube F serves as an equalizer of pressure, as hereinafter described. N shows a common tube thermometer attached to the standard for convenient reference.

Before using the apparatus, the reservoir D is supplied with water, and by means of the compressing bulb E, the burette and pipettes are filled to their zero marks, and their respective stopcocks closed, the stopcocks connecting *c* and F being closed meanwhile. The stopcock connecting *c* is now opened, and the bottle B filled a little above a zero mark upon the tube *b*, which for a portion of the way is of glass; this glass tube being so inserted in the rubber stopper that the bottle may be entirely filled with water without air space. During the filling of B, the stopcock M should be opened, connecting as it does with the air space surrounding the gas bag within the bottle C, while the generating bottle A should be disconnected and the gas bag collapsed. When B is filled, the stopcock connecting it with L is closed, and that at F opened, and this tube filled in like manner to a point higher than the zero mark of B, when the stopcock connecting *d* is closed, and that at *c* opened again. The generating bottle A with its charge of sample and acid in the tube, is now connected, and through the stopcock connecting *d* the level of the water in B adjusted to the zero mark, that in F subsiding with it. When the adjustment is thus effected, the stopcock connecting F, and that at M are closed, while that connecting with the reservoir through *d*, is opened, and thus free course given for the water between B and D. The bottle B being elevated upon the shelf O, there is of course a reduction of pressure within the apparatus, causing a subsidence of the water level; which after a few moments should cease, showing that the apparatus is tight in every joint. If, however, this is not the case, and the level continues to subside, there is a leak, which must be corrected and a readjustment of pressure effected before the operation is continued.

* By an error of the engraver this pipette is marked 300 cc. It should be 400 cc.—Ed.

When all is in readiness, the decomposition of the carbonate is effected in A by bringing the acid and carbonate together in the usual way, the temperature having been noted at the outset. The evolution of the gas, distending the rubber gas bag, expels a portion of the air from C, which forces the water from B into the reservoir D, in volume equivalent to the gas evolved at the pressure and temperature prevailing, as is readily understood. When complete decomposition is effected, and the temperature in A returns to the temperature of the room, by means of the bulb E, pressure is exerted upon the reservoir D, and the stopcock connecting F being opened, the levels in B and F are brought together through the stopcock connecting *d*.

When this is accomplished, the stopcocks at F and *d* are closed. It is seen that the displacement of the water in B obtained in this manner is exactly that of the volume of the gas evolved from the carbonate at the existing temperature and atmospheric pressure. With all stopcocks closed, excepting that connecting *c*, and that at M which should now be opened, the bottle B is removed from its shelf to the table upon which the apparatus stands, and the amount of the displacement measured by running in the contents of such of the pipettes, and portion of the contents of the burette, as may be required to restore the water level in B to the starting point, the amount of water thus employed of course being that measure.

From the volume of gas obtained, the percentage by weight of the sample taken is calculated in the usual way, either by the formula for correction of volume for temperature and pressure, adding of course to the volume thus obtained a correction for carbon dioxide dissolved in the decomposing liquid, or through the use of the tables given originally by Dietrich, (*Ztschr. anal. Chem.*, **4**, 141). It is to be noted, however, that these tables are not strictly correct, the weight of the cubic centimeter of carbon dioxide at 0° C. 760 mgms. being considerably at variance with that at present given by the best authorities, and some slight errors, in the calculation apparently, are also to be observed. In ordinary work, however, these are not important. But in the use of the table given for solubility of the gas in the decomposing acid, one must exercise no little caution. In fact

for this correction, it is better to establish for one's self just what it should be for each material operated upon, by check gravimetric determinations; for while within limits this may be taken as a constant factor, yet it is more or less affected by the character of the salts present. And further, this table was not carried far enough to cover the large volumes of gas evolved from the charges that my apparatus enables one to employ.

With this apparatus it is possible to make a determination of carbon dioxide in from ten to fifteen minutes, and that with extreme accuracy. Indeed with the large charges one may employ, and with careful weighings, repeated results obtained from the same sample, will never vary more than one-tenth per cent. and scarcely more in most instances than two or three one-hundredths per cent.

ARE PENTOSES FORMED BY THE ASSIMILATION PROCESS?[1]

DR. G. DE CHALMOT, AGRICULTURAL DEPARTMENT, RICHMOND, VA.

IN recent years the chemistry of the sugars having been revolutionized by the investigations of Kiliani, Fischer, Tollens, and others, the study of the assimilation process, by which the carbohydrates in the plants are originally formed, has also received a new interest.

The theory of Bayer, according to which the first product of the assimilation is formaldehyde, has recently received a very strong support by the results which Bokorny obtained.[2]

Fischer observed some years ago that glyceric aldehyde was probably an intermediate product in the assimilation process, since it most readily unites with itself, yielding hexoses, when placed under proper circumstances.[3]

Pentosans, substances which yield pentoses by hydrolysis, are most widely distributed in plants and form often a large part of their dry matter.[4] The pentoses, xylose, and arabinose, belong to the laevo series (of Fischer) in contrast with the more

[1] Read before the World's Congress of Chemists, August 23, 1893.

[2] *Ber. d. bot. Ges.*, 9, 4, 103.

[3] *Ber. d. chem. Ges.*, 23, 2238.

[4] *Am. Chem. J.*, 15, 21, note.

widely spread hexoses, glucose, and laevulose, which belong to the dextro series.

From a chemical point of view it is more likely that the laevo-pentoses and dextro-hexoses are formed beside each other by the assimilation process, than that they are formed out of each other. The theory of Bayer thereby admits just as well the formation of pentoses as that of hexoses. On the other hand, strong support will be given to Fischer's theory that glyceric aldehyde is an intermediate product, if it be proved that the pentoses in plants are not formed by the assimilation process. I have, therefore, investigated this subject, and I have reached results which prove that pentoses are not formed by the assimilation process unless in imperceptible quantities. Let us see how this result was obtained.

Of the methods used for the quantitative analysis of the pentoses I can only say a few words. Pentoses yield, as is well known, about fifty per cent. of furfurol when heated under proper circumstances with dilute hydrochloric acid. Upon this property the methods for determining pentoses are based, since they vary only in the way in which the furfurol is estimated.

Two different methods were used. When larger quantities of pentoses are present, I used the method of Tollens and myself with the alterations recently proposed by Tollens and Flint. By this method the furfurol is precipitated and weighed in the form of hydrazon. This method when properly executed gives very accurate results. If only very small quantities of pentoses are present in solutions, the furfurol is determined by a colorimetric method making use of its property of yielding a red dyestuff when mixed in an acetic acid solution with an alcoholic solution of anilin oil in the absence of free mineral acid. This method was published in the American Chemical Journal of this year.[1] Since hexoses also yield small quantities of furfurol when heated with hydrochloric acid, for examples, fructose (0.2 per cent.), glucose, and galactose (0.04 per cent.) it is necessary to determine also the total amount of sugars if only very small quantities of furfurol are obtained, in order to be sure that pentoses are present. I considered that the pentosans known

[1] *Ibid*, 15, 25 and 277.

to exist in plants are insoluble in water and can not, therefore, be removed as such. As it is a matter of course that if the pentoses are formed in the leaves they must migrate to other parts of the plants, since we find them there, I looked for easily soluble pentoses. I therefore made extracts of the parts to be investigated by immersing them in water, and was able to trace in the leaves of thirty-five plants belonging to widely different families and also in the colorless bark soluble pentoses.[1] I concluded that soluble pentoses occur universally in green higher plants.

These soluble pentoses diffuse readily through membranes permeable to water, as parchment paper and parchment. They furthermore do not diminish perceptibly in dying leaves. For these reasons the soluble pentoses are true transport substances. They are, however, present in much smaller quantities than the soluble hexoses. The largest amount found was 0.4 per cent. in the leaves of Tecoma radicans. In many instances the amount does not exceed 0.05 per cent.

If the pentoses are formed by the assimilation process, they are either removed as soon as they are formed or they are temporarily stored, probably in an insoluble form and gradually removed. If the pentoses are removed as soon as they are formed, there ought to be much more soluble pentoses in the leaves during the time of the assimilation than after that time. I therefore collected of the sycamore and the oak the same surface of leaves at half-past four and ten o'clock in the morning and at five and nine in the afternoon. The oak leaves contained at sunrise slightly less soluble pentoses than at other times of the day. In the sycamore leaves I could not perceive any difference. The pentoses are therefore not as quickly removed as they are formed, a fact which was probable from the beginning. I made nine investigations of oak leaves and found in seven instances slightly more soluble pentoses in the evening than at sunrise. In one instance the leaves contained less soluble pentoses in the evening, but then the specimens of morning and evening leaves did not exactly agree. A small difference seems therefore evident, a

[1] *Ibid*, 15, 21.

difference amounting to from 0.01 to 0.02 per cent. of the weight of the fresh leaves. In leaves of other plants I have not been able thus far to detect the same difference. I therefore concluded that the pentoses are temporarily precipitated in the chlorophyl grains and gradually removed. In the oak leaves the pentoses assimilated during the previous day should be nearly or fully removed at sunrise.

The idea that the pentoses are temporarily precipitated mixed with hexoses as starch of assimilation is not so improbable since Winterstein found pentosans which are soluble in boiling water and give a blue color with iodine.[1] Moreover, I was able to prove that the insoluble pentosans in seeds are resolved during the germination and removed into the germs. Notwithstanding all this, this hypothesis is wrong, as I have proved beyond doubt that no such accumulation of pentoses in the leaves takes place.

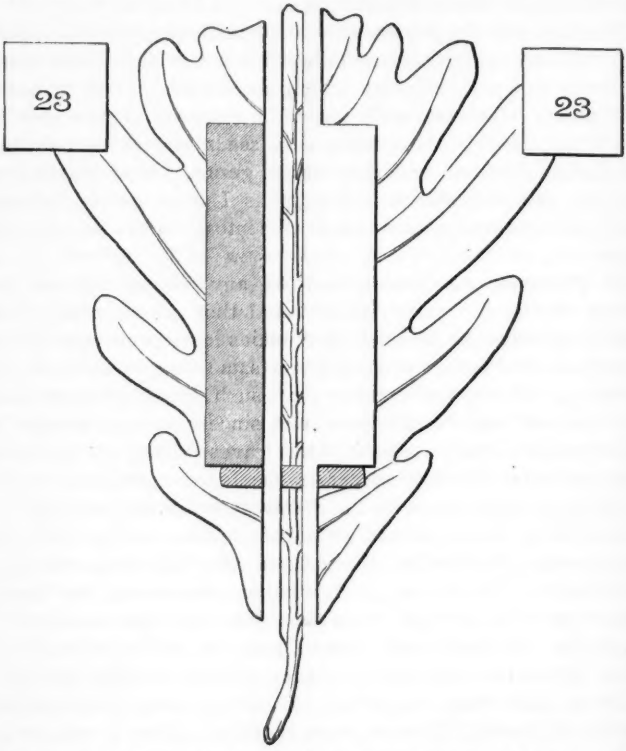
If pentosans are transported to any extent out of the leaves during the night we will find that a certain surface of leaves collected in the evening contains more pentosans than a closely similar surface of exactly the same size collected in the morning. If, on the contrary, no such transportation takes place we will find no difference, and since a certain amount of dry matter is transported out of the leaves during the night we will find that the dry matter in the leaves contains a smaller percentage of pentosans in the evening than in the morning.

For these investigations I used the method of leaf halves of the German physiologist, Sachs,[2] and collected my specimens as indicated in the drawing. I number from 70 to 100 leaves, attaching with varnish on both halves the same number. I make on the lower part of each leaf also with varnish a little mark across the mid-rib. At seven o'clock in the evening I sever a piece from every leaf by cutting close to and paralell with the mid-rib. Out of each of these pieces I cut with a razor a strip the form of which is given by a piece of iron plate. This is applied with one of its long sides along the cut, and with its lower end touching the mark. Each strip receives the

[1] *Ber. d. chem. Ges.*, 25, 1237.

[2] *Vorlesungen über Pflanzenphysiologie*, 304.

same number as the leaf from which it is derived on a strip of paper which is wrapped around it. The strips of leaves are then quickly dried at 100° C. The next morning at half past three I collect, number and dry the symmetrical strips of the other halves of the leaves. The numbers of strips of both series are then compared and those strips taken out of which the



counterpart fails, which will sometimes happen, since one of the times of collection is before sunrise. The difference in weight of both lots of dried strips gives very accurately the total amount of dry substance removed during the night or stored during the day in the case in which I collect the first lot before

sunrise and the second in the evening. The dried strips are then pulverized and exactly the same quantity of each taken for the estimation of the pentoses. Both analyses are made side by side and with the utmost care. I have put together in the following table the different results obtained:

	Evening.		Morning.				
	Weight of 1 sq. meter of leaves.	Per cent. of pentosan.	Weight of 1 sq. meter of leaves.	Per cent. of pentosan.	Total amount of assimilation products stored in 1 sq. meter of leaves.	Excess of pentosan in 1 sq. meter of leaves in the morning.	Excess of pentosan in 1 sq. meter of leaves in the evening.
	gms.	gms.	gms.	gms.	gms.	gms.	gms.
Corn (Zea Mays) I.....	33.456	14.49	28.633	17.26	4.823	0.098	.....
II.....	35.354	15.35	31.644	17.21	3.710	0.018	.....
Oak (Quercus alba) I...	70.343	6.77	66.977	7.16	3.366	0.030	.....
II...	57.90€	7.86	55.493	8.30	2.413	0.060	.....
Tropaeolum majus.....	26.143	4.01	23.401	4.42	2.742	.....	0.014

Corn promised to be a favorable subject as the leaves are thin and assimilate strongly. This plant contains large amounts of pentosans, 17 per cent. in the leaves and 11.5 in the stems. The first investigation showed that one square meter of leaves weighed in the evening 33.456 grams and in the morning 28.633 grams. During the night 4.823 grams were removed and still one square meter of leaves contained in the morning ninety-eight mgms. more pentosans than in the evening. As it seemed possible that a small amount of pentosan was formed during the night in the leaves I collected in my second investigation first in the morning and afterwards in the evening, I found that one square meter of leaves had stored during the day 3.710 grams of dry matter, but no pentosans, since eighteen mgms. more were found in the morning, which difference is well within the limits of experimental error. Oak leaves had also to be investigated, as little difference was found in the amount of soluble pentosans in morning and evening leaves. They offer a much less favorable subject than corn leaves, since they are thicker and do not assimilate as strongly. Oak plants are, however, also rich in pentosans. The leaves, it is true, contain only from seven to eight per cent., but the stems, which weigh far more, are also much richer in these substances. The stems of the shrubs which I used contained nineteen per cent. of pentosan.

In the experiments made I collected first in the evening and afterwards in the morning. The plants used for the two experiments belonged to two different localities. The results of both investigations showed slightly more pentosans in the morning, but the differences found do not exceed the limits of experimental error. The seeds of tropaeolum majus contain a pentosan that is soluble in boiling water and conducts itself also in other respects as starch. I therefore experimented also with this plant. The plants contain but little pentosan, the leaves 4 per cent., and the stems 6.5. The leaves are very thin, and therefore I was obliged to take 300 leaves in order to obtain enough substance for the estimation of the pentosans. These leaves were cut during several evenings and nights in succession. One square meter of leaves lost during the night 2.742 grams of dry matter, but only fourteen mgms. of pentosan.

All these investigations show that an accumulation of pentosans in the day time and transportation of the same during the night does not take place. The pentosans therefore are not formed by the assimilation process, unless in such imperceptible quantities as can not explain the large amounts that plants contain.

The theory of Fischer, according to which a formation of pentoses by the assimilation process is improbable, thus receives unexpected support.

IMPROVEMENTS IN THE MANUFACTURE OF SULPHURIC ACID.

By Peter S. Gilchrist.

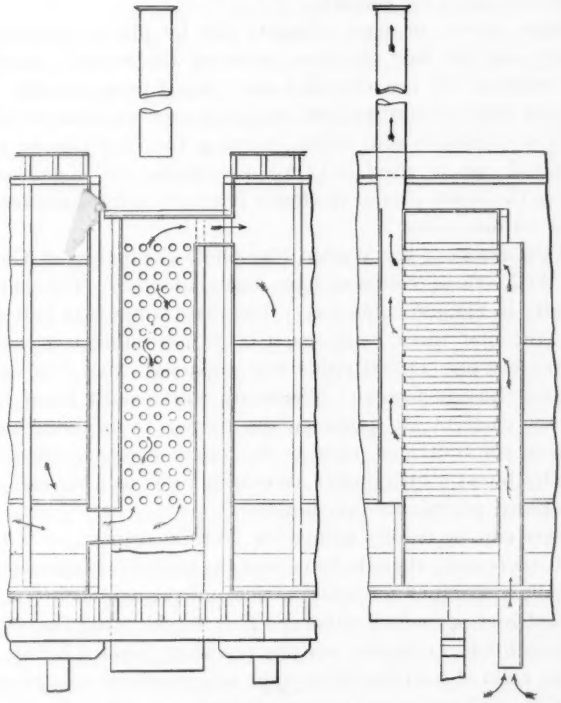
Received September 11, 1893.

ANYTHING tending towards cheapening the cost of producing sulphuric acid has now become of vital importance to chemical manufacturers. The chief source of improvement lies in the reduction of the large chamber space necessary for condensation, owing to its cost and maintenance. This has been attained in several ways.

A simple but very effective method has been devised by Hacker and Gilchrist, which has been attended with very satis-

factory results, their device having been covered by patents in this country and in England.

DEVICE FOR SAVING CHAMBER SPACE.
Hacker & Gilchrist's Patent.



The gases in passing from one chamber to another, are drawn through a leaden tower, called a pipe column. This column is filled with horizontal lead pipes burnt to the sides, and so placed as to continually break the course of the gases, but at the same time allow them to pass.

Through the horizontal pipes, air of ordinary temperature is drawn, by means of a chimney, or preferably by artificially cold air forced through by means of an air pump.

During the passage of the gases through these columns they

are thoroughly mixed, a strong reaction resulting, consequently heat is evolved. This heat is carried off by means of the cold air passing through the pipes. Moisture is supplied by steam entering into the column along with the gases, or by running weak acid down the column.

These towers or pipe columns can be placed between the Glover and the first chamber, between the several chambers, and between the last chamber and Gay-Lussac towers. The object of this last position is to cool the gases, and remove the last traces of sulphuric acid before entering the Gay-Lussac tower, so that it can be used fully for absorption, for in so many instances the lower part of the tower is simply lost for the recovery of the nitrous gases.

At the works of the Wando Phosphate Company, of Charleston, S. C., these columns have been adopted. The chamber capacity is 246,400 cubic feet. The plant consists of four chambers, the first three being each of 78,400 cubic feet capacity, and the last one 11,200 cubic feet capacity, with Glover, and two Gay-Lussac towers. There are thirty-eight lump pyrites burners, each of 750 pounds capacity per twenty-four hours of fifty-two per cent. ore, making the chamber space for sulphur actually burnt a little under seventeen cubic feet per one pound of sulphur, per twenty-four hours.

There can be readily added six additional furnaces to thirty-eight, increasing them to forty-four, as chambers three and four are simply storages for nitre, almost all the acid being made in the first and second chambers. This would bring the capacity down to fifteen cubic feet per one pound of sulphur burnt.

The yield of acid has been in the neighborhood of 4.75 pounds of 50° B. acid per one pound of sulphur. As the pipe columns were added to a plant already built, they could not be placed to the best advantage; the first three chambers being 160 feet long, the pipe columns are at too great a distance from each other, so are not as effective as if in conjunction with smaller chambers.

These pipe columns need little attention, as the steam being regulated by the strength of the drip, when once regulated need not be touched, if the steam for the chambers is supplied through a self-regulating pressure gauge.

The advantage of the pipe columns in warm climates is very great, the yield of acid per chamber space being largely increased, thirty to forty-five per cent., according to the number of pipe columns used. The yield of acid per quota of sulphur is also increased, and a saving of nitre is effected. These towers being made of lead, are not very expensive, so are likely to become adjuncts to many chambers, especially as they can be added to existing plants.

Since this paper was written, I have planned two new acid plants, saving chamber space by means of the foregoing device; these two plants are now under course of construction.

CHARLESTON, S. C.

THE EDUCATION OF INDUSTRIAL CHEMISTS.[1]

BY HENRY PEMBERTON, JR.

SOME years ago a chemical firm in one of our eastern cities was desirous of obtaining the services of a chemist, who should take charge of the factory. Accordingly, advertisements were inserted in the industrial journals, for a man who should not only be familiar with the analytical work necessary, but who could also assume the responsibility of overseeing the plant, checking the running of the various processes, and meeting the emergencies that are constantly arising in operations of this kind.

A large number of answers were received. Interviews were requested with those who, from their letters, appeared to be the most likely to suit. But as a result, it soon appeared that the securing of a competent man was by no means an easy matter. Some of the applicants, whose letters were most assuring, turned out to have been simply laboratory boys. Others, more promising, were of foreign birth, but unfamiliar with the language and customs of this country. Some were undesirable on account of their personal manner or character. But, by far the most general objection, was that the knowledge and experience of these chemists were limited to the field of analytical chemistry, and to the work of the laboratory. They were entirely familiar with the handling of beaker glasses and funnels, plati-

[1] Read before the Worlds' Congress of Chemists, August 26, 1893.

num crucibles, analytical balances, burettes, and flasks. But in the matter of treating material *in large quantities*, and obtaining results in the factory, they came up, as it were, against a stone wall. Many of them, in fact, were literally as unfamiliar with the operations of a chemical plant as they were with the working of an astronomical observatory.

It should be observed that the case here described, is by no means an isolated one. There is reason to believe that there is hardly a large chemical manufacturer in the country who, at one time or other in his life, has not had experiences of a nature similar to this one.

It will be admitted that the question of technical education is a most important one. It deserves at least as much attention in the United States as it does elsewhere, on account of the remarkable progress and development of industrial activity here. It will be shown in the forthcoming report of the United States Census of Manufactures, that the chemical industry has experienced a more diversified and extended growth than is peculiar to any other branch of productive industry in this country. Owing to the richness of our resources (which we have always enjoyed), and owing especially to the beneficent effects of a high tariff (which we have enjoyed for three decades) the capital invested, the wages paid, and the value of the chemicals and allied products manufactured, represent in the aggregate a degree of prosperity that is most flattering.

It is for this important field then, that the universities and technological schools of the country, prepare their young men. And it is because the quality of this technical talent is so frequently below what is called for, that I venture to draw attention to certain considerations on the subject, that may be of interest.

The method of teaching applied chemistry as now generally practiced consists in describing, in a series of lectures, the manufacture of so many of the various acids, bases, and salts as the professor can find time to present. Sometimes certain industry groups are selected, such as soda chemicals, explosives, dye extracts, coal tar products, and so on. But it is evident, on account of the endless array of chemical products, that it is

impossible to cover the ground in any but the most superficial manner. It is also an even chance whether the student will ever afterwards be engaged in any of the few industries thus outlined by him in his lecture note book.

It should again be stated that the usual method of instruction consists in describing the manufacture of certain *products:* the preparation of this salt, of that acid, or of that dye. It is invariably upon a series of such products that the classification of the lectures is based, and it is because the name of these chemicals is legion that the instruction must necessarily be incomplete and the knowledge gained vague and indefinite. While such instruction is, of course, better than none, and indeed should still be continued, it should be relegated to the position in the curriculum to which it properly belongs, as being a part of the course in general chemistry adapted to all chemical students, but should not be the only groundwork for the training of the future technologist.

What is it that such a young man sees on entering one of our large chemical factories? He observes, on all sides of him, apparatus and machinery for grinding material, for elevating and transporting it. He sees materials under treatment in various ways, and at all stages. He notices that in one building or department such and such operations are performed—it may be the solution of some article here, the filtration and washing there. Here he sees the processes of evaporation, or it may be of crystallization or perhaps of distillation and condensation. Elsewhere he observes a series of calcining furnaces. In another part of the works are the drying rooms. Many other processes he notices in full operation, the object of which, and perhaps of the very name of which, he is ignorant. The thought that is likely to be deeply impressed upon his mind is—"Why was I taught nothing of this in college?" His mortification is apt to be all the greater when he perceives the number of workmen about him who understand it all. There are foremen, heads of departments, machinists, carpenters, and others, no one of whom, perhaps can write a letter correctly, and yet all experts in their several lines; while he, a university graduate, has not even been taught the use of the tools of his trade.

It is evident that some system of instruction is necessary that is essentially different from that now in vogue. And it is the object of this paper to outline such a plan, which, it may be stated at once, *consists in the teaching, not of products, but of processes, and in directing the attention not so much to the chemical, as to the apparatus.* The subject can be discussed most clearly by presenting it under three headings: The lectures, the practical work, and the text book.

The Lectures.—Prof. Tyndall once observed that a man who had thoroughly mastered a scientific principle was in possession of a key that would open many locks. A somewhat similar idea is here applicable; the important point being to place the learner in possession of the knowledge of one particular class of operations at a time, and to make that knowledge comprehensible and thorough, so that its application to any variety of purposes may be possible.

For example, let a series of lectures be given upon the reduction of materials to a fine state of division. The many kinds of crushers, chasers, mills, disintegrators, and beaters should be described, especial attention being given to explaining the peculiar adaptability of each kind of such machinery to the physical properties of the substances to be treated. A thorough description of the practical working points of each type of mill should be laid before the student. In the case of an ordinary pair of forty-eight inch buhrstones for example, he would be taught such facts as the average horse power required to drive them, the usual output of the mill per hour, the speed at which it runs, the dress of the stones, and the different qualities of materials from which they are made. The use of screens and bolting cloths would be touched upon, as well as the methods of handling the tailings. Some mills he would observe are capable of yielding a product large in quantity, but coarse in quality, while others can be used only under conditions exactly the reverse. Some forms of apparatus like the disintegrator, can treat a damp or plastic material, such as a superphosphate or sulphate of alumina, while others will handle dry and brittle substances, only, to advantage.

An understanding of the essential principle upon which each

of these forms of apparatus works would thus be obtained by the student, who would be able to apply the information, it may be years afterwards, in some distant fertilizing factory in Georgia, or in some remote refining works in the far West.

Continuing the same line of thought another series of lectures would be given upon filtration, frequently one of the most difficult of technical processes. It could be shown how a coarse open substance (like black ash for instance) can be washed in masses of considerable depth, while others, of a closer or denser nature, like lime-mud, or calcium sulphate, must be handled in what, to the tyro, would appear to be amazingly thin and extended surfaces. It would be pointed out how some substances, like gelatinous hydrate of alumina or precipitated ferric hydrate, cannot be filtered at all, practically, on a large scale, but must be washed by decantation. The construction of filters, the selection of proper materials for the filter bed, the application of a vacuum, the handling of the different wash waters, the use of filter presses, and of centrifugals, all of these matters would be discussed in sequence. This would form a scientific classification of the subject that would be valuable to the student, enabling him to apply the information to the preparation of any kind of chemicals, let them be fine pharmaceutical preparations, or heavy bulky goods that are made in large quantities.

The methods of evaporation of liquids could next be studied, describing the plant necessary for underheating, for surface heating, and for coil evaporation. The treatment of solutions with gases, the methods of uniformly mixing solids with liquids, the erection and use of reverberatory furnaces, the transportation of solids by elevators, conveyors, belts or link chains, the lifting of liquids, acid or alkaline, by pumps, injectors, or compressed air; in a word, all the important processes in use in chemical engineering would each, in turn, form the subject of a series of lectures.

In teaching applied chemistry in this manner the important point gained is that the learner's mind is occupied by one class of subjects, or processes at a time, thus giving him a practical knowledge of each important department of manufacturing

chemistry, *entirely irrespective of what kind of goods are produced.* This is in sharp contrast to the present systems, in which his mind is bewildered by the numerous details involved in the description of a heterogeneous series of chemicals. He perceives that the forms of apparatus in use in the factory are simply so many tools, the construction and use of which he must learn in order to obtain results, and that when equipped therewith he is "in possession of a key that will open many locks."

The Practical Work.—The study of analytical chemistry, although an excellent training for the mind, has one element of weakness: the learner is taught to depend entirely upon authority. He is obliged to follow out, to the very letter, the methods prescribed in the text book. As a result, he necessarily foregoes any attempt at original work, and as a specialist in analytical chemistry is frequently (in fact almost always), incapable of supervising any work other than that of the laboratory.

The remedy for this is to catch the chemist when he is young, and introduce him to the methods used on the large scale. It is seldom possible to obtain for a student the entrée to a chemical works. Such a request is generally declined without thanks. And as the chemical works cannot be brought into the college, it remains that there be established there certain methods of work requiring the same processes of reasoning and the same methods of attacking the problems that are in use in the actual factory.

The important facts so far as *apparatus* is concerned, can be obtained from the lectures, and still more fully from the text book. But in regard to the methods of working, valuable information can be had from synthetic experiments of the simplest nature. And it is in such investigations that the student should be well drilled. As an example of the points that can be illustrated in this manner, let a student be required to make, for instance, some copperas, for which purpose he may be furnished with a few ounces of iron nails, some oil of vitriol, a number of large dishes and a funnel. He determines the strength of the acid, using both Twaddle's and Beaumé's hydrometers, thus

learning the use of these instruments. Converting this into specific gravity he obtains from the tables the percentage of actual SO_3 in the acid, and from that the volume of vitriol required for the given weight of iron. He next calculates the quantity of water necessary to supply the water of crystallization of the salt, as well as that required to hold it in solution, and by this means becomes familiar with the use of tables of solubilities. After solution of the iron and filtration, he measures the total bulk of the liquid, which is then evaporated to the crystallizing point, and again measured. The conditions most favorable to crystallization are now studied, the weight of crystals obtained and the percentage yield as compared with that of theory, computed. Analysis of the mother liquor will check this, and will familiarize him with the method of calculating milligrams per cubic centimeter into pounds per cubic foot.

He is now in position to estimate the size of the vessels necessary to treat a batch of say 1,000 pounds of iron, and can, on paper, erect a dissolving tub, filter, evaporating tank, and crystallizer, all of the proper shape and proportion. The best thickness of lead for lining these tanks can be determined, its weight calculated and also its cost. Assuming a price for the iron and vitriol, the cost of these ingredients per ton of crystal can easily be figured out. And all of this from a bottle of acid and a few ounces of iron nails.

This little example is given merely as an illustration of what kind of work can be done. It can of course be varied in many ways and with many materials. It matters not a particle upon what salt or preparation the student is put to work. As a matter of fact the above example would never be put into practice on the large scale, since copperas is nearly always produced as a by-product from other operations, or is made by the weathering of marcasite.

But the training that he obtains will teach him the importance of observing the physical properties of substances in the various stages of treatment. By discovering the difficulties to be met he acquires the art *of making mistakes on the small scale.* The lack of such experience has undoubtedly been the cause of the loss of immense sums of money in many instances.

The Text Book.—To this entire subject of industrial education, as herein described, there is one objection that may be made, namely: What is to prevent such a series of lectures becoming antiquated and out of date in the course of a few years? The answer is to be found in the literature of the subject. How many text books on qualitative analysis are there in existence? As every chemist knows, they are numbered by the score, if not by the hundred. In what important particular does any one of these text books differ from the others? What new fact does it contain? If, now, a subject so utterly thrashed out as qualitative chemical analysis can thus be again and again discussed, what is to prevent the establishment of a series of treatises on chemical technology, by which the whole subject can be brought under control and properly classified? It is important to note that such treatment of the subject would of necessity be *cumulative*. The experience of one writer would thus be collected and embodied in the treatise of another. The weak points of one text book would be made good in its successor, or in the second edition. The mere fact that no such treatises are in use to-day is precisely the most imperative reason why they should be introduced.

Such a manual would follow the methods indicated in the foregoing. Its object would be to describe not products, but processes, and it would be to the apparatus and methods of treatment that attention would be given. It is needless again to go over the ground previously covered, more than to say that each particular class of operations in use in a factory would be treated separately in its proper chapter. In other words, the book would supplement the lectures. The illustrations and plans to scale would describe actual working apparatus and the student would be taught how to handle precipitates and solutions by the ton, just as, in analytical work, he learns to manipulate them in quantities represented by the gram and cubic centimeter.

In addition to such a treatise, the student should be allowed the use of the various journals on chemical technology that are published in the English and German languages. To these should be added the trade journals, of which there are quite a

number, and even such material as manufacturer's catalogues and illustrated price lists will be found to contain information of much value upon subjects relating to the supplies needed in all factories.

In conclusion it may be acknowledged that this plan of instruction is essentially a utilitarian one. This is in accordance with the general drift of the scientific education of to-day. To use Lord Bacon's expression the aim is to gather fruit, not flowers. The training of the mind will incidentally be one of the results of such a system. But the main object will be the imparting of actual knowledge and the teaching of specific facts. The manufacturing chemist who has to meet the difficulties that constantly arise in the practice of his profession is like a man who is lost in the Alps. What he wants, is not to improve his mind, but to find the way. The present system of instruction does not meet the requirements made upon it. It teaches the principles of the science but does not go far enough. As Macaulay said of the ancient philosophers, every trace of intellectual cultivation is there except a harvest. The subject of industrial chemistry evidently has not received the attention it deserves in our schools of science.

PHILADELPHIA, PA.

THE DETERMINATION OF CASEIN IN COWS' MILK.

BY L. L. VAN SLYKE.

Received August 31, 1893.

THE methods originally proposed by Hoppe-Seyler and Ritthausen have been commonly employed for the separation and determination of casein in cow's milk. In both methods, the milk is diluted with water and a small amount of acetic acid is added. The precipitation is rendered complete, in one case, by raising the temperature to 40° C., and, in the other case, by passing a current of carbon dioxide through the mixture at ordinary temperatures. The precipitate is filtered, washed first with water, and then with ether to remove fat and is finally dried and weighed on the filter. The absence of specific directions touching several steps of the operation led me to investigate some of the conditions pertaining to the determination of casein, among which were the following:

1. Comparison of the two methods.
2. Influence of amount of acid used in precipitating casein.
3. Use of different acids in precipitating casein.
4. Influence of temperature and time of digestion on precipitation of casein.
5. The precipitation of casein in fresh and in old milk.
6. The use of preservatives in keeping milk, and influence on the determination of casein.

The tedious method involved in washing the precipitated casein free from fat by ether and in subsequent drying and weighing on the filter paper was entirely discarded. The precipitated casein was washed by decantation and on the filter two or three times. The filter and contents were then treated by the ordinary Kjeldahl method for the determination of nitrogen, the factor 6.25 being used to convert the amount of nitrogen into an equivalent of casein, when this was desired. This use of the Kjeldahl method in determining the amount of casein was suggested and employed sometime since by several chemists and is now very generally used in the analysis of dairy-products. The advantages of its use over the old method in point of accuracy and simplicity are too evident and too well known to deserve further mention. Much credit is due to Mr. A. L. Knisely who has done valuable work in carrying out the analytical details of the investigation.

(*1*) *Comparison of Results Obtained by Precipitating Casein in Milk at a Temperature of 40° C. without Carbon Dioxide and with Carbon Dioxide at Ordinary Temperatures.*—The method employed in making the comparison was, briefly, as follows: About ten grams of milk were used in each case. This amount of milk was diluted with water at 40°–42° C. to 100 cc. and then 1.5 cc. of a solution containing ten per cent. of acetic acid were added and the solution was carefully stirred with a glass rod. The resulting precipitate was washed two or three times by decantation and on the filter; finally, the filter-paper and contents were digested according to the Kjeldahl method for determining nitrogen. In the other case, the milk was diluted to 100 cc. with water of the temperature of the room, then 1.5 cc. of the same dilute acetic acid as that employed above were added,

after which a stream of carbon dioxide was passed through the solution, until the liquid above the precipitate was clear or very nearly so. The subsequent filtration, washing, and determination of nitrogen were made as above.

The following results were obtained by the two methods with two different samples of milk, triplicate determinations being made in each case:

Method A, precipitation at 40° C., sample No. 1.	Method B, precipitation with aid of carbon dioxide, sample No. 1.
(a) 0.475 .... per cent. nitrogen	(a) 0.486 .... per cent. nitrogen
(b) 0.474 .... " " "	(b) 0.480 .... " " "
(c) 0.469 .... " " "	(c) 0.461 .... " " "
Average 0.473	Average 0.476
Sample No. 2.	Sample No. 2.
(a) 0.458 .... per cent. nitrogen	(a) 0.454 .... per cent. nitrogen
(b) 0.458 .... " " "	(b) 0.444 .... " " "
(c) 0.449 .... " " "	(c) 0.455 .... " " "
Average 0.455	Average 0.451

Statement of Results.—The above results indicate: First, that essentially the same results are obtained whether we precipitate the casein in cows' milk at a temperature of 40° C. without carbon dioxide, or at ordinary temperatures with the aid of carbon dioxide, other conditions being uniform. In sample No. 1, the results differed by 0.003 per cent. of nitrogen; in sample No. 2, by 0.004 per cent. of nitrogen, the excess being first with one method and then with the other.

Second, that the individual results obtained by several determinations of the same milk agree closely by either method, somewhat closer concordance being given by precipitation at 40° C. Thus, in sample No. 1, the greatest difference in three determinations was 0.006 per cent. of nitrogen at 40° C., and 0.025 per cent. nitrogen with the other method. In sample No. 2, the greatest difference was 0.009 per cent. nitrogen at 40° C. in three determinations, and 0.011 per cent. nitrogen with the other method.

(2) *Influence of Amount of Acid Used in Precipitating Casein.*—The acid used was a solution containing ten per cent. by weight of acetic acid. This dilute acetic acid was used in amounts

varying from 0.5 to 5 cc. To about ten grams of milk, sufficient water at 40°–42° C. was added to dilute to 100 cc. and the acetic acid was then added. The operation was completed in the manner described above.

Below we present the analytical results tabulated:

	Amount of acid used.	Character of filtrate.	Per cent. of nitrogen found in the precipitate.
Sample No. 1	0.5 cc.	slightly cloudy	0.458
	1.0 "	clear	0.458
	2.0 "	clear	0.449
	3.0 "	clear	0.441
Sample No. 2	1.0 cc.	clear	0.475
	1.5 "	clear	0.474
	2.0 "	clear	0.469
	3.0 "	slightly cloudy	0.450
Sample No. 3	0.5 cc.	milky	0.117
	1.0 "	quite cloudy	0.471
	1.5 "	clear	0.545
	2.0 "	clear	0.550
	2.5 "	clear	0.545
	3.0 "	clear	0.537
	4.0 "	slightly cloudy	0.527
	5.0 "	milky	0.340
Sample No. 4	0.5 cc.	milky	0.059
	1.0 "	slightly cloudy	0.551
	1.5 "	clear	0.550

Statement of Results.—The data presented in the preceding table indicate:

First, that in one sample 0.5 cc. of acid gave a maximum amount of nitrogen in the precipitate, while in two other samples, the amount of nitrogen obtained in the precipitate was very low. In each instance where the lowest results were given, the filtrate was milky in appearance.

Second, that in three samples out of four, the use of 1.0 cc. of acid gave highest results, the filtrate being clear or only faintly cloudy.

Third, that, in most instances, the use of 1.5 cc. of acid gave the highest results, with a clear filtrate in every case.

Fourth, that the use of two cc. of acid gave very nearly the same results as the use of 1.5 cc. of acid in most cases, the filtrate being clear.

Fifth, that the use of 2.5 cc. or more of acid gave lower results, the decrease becoming greater with increase of acid and the character of the filtrate becoming more turbid in appearance.

Sixth, that, with fresh milk, the best results can be secured in determining casein by using from one to two cc. or, in general, 1.5 cc. of a ten per cent. solution of acetic acid.

Seventh, that the completeness of precipitation is quite fairly indicated by the character of the filtrate. When the precipitation is incomplete as a result of using too little acid, the filtrate will be more or less turbid, varying from opaque milkiness to barely perceptible cloudiness. If, on the other hand, an excess of acid is used, thereby causing more or less casein to remain in solution, the filtrate will be more or less turbid according to the amount of casein in solution. In some cases, a filter paper may allow some precipitated casein to pass through and render the filtrate turbid. In such cases, two or three repeated filtrations generally serve to remove the casein and to give a clear filtrate.

(3) *The Use of Different Acids in Precipitating Casein.*—In order to ascertain whether some other acid could be used to precipitate casein more effectively than acetic acid, comparative trials were made with solutions containing ten per cent. of the following acids: (1) acetic, (2) lactic, (3) sulphuric, (4) hydrochloric. Below are given the results of the comparative trials:

Kind of acid used.	Amount of acid used.	Character of filtrate.	Character of precipitate.	Per cent. of nitrogen in precipitate.
Acetic acid	1.5 cc.	clear	flocculent	0.395
Lactic acid	0.5 "	milky	"	0.074
" "	0.75 "	slightly cloudy	"	0.396
" "	1.0 "	clear	"	0.394
" "	1.5 "	milky	"	0.268
Acetic acid	1.5 cc.	clear	flocculent	0.465
Sulphuric acid	0.5 "	clear	s'ewh't gelatinous	0.470
" "	0.75 "	clear	" "	0.457
" "	1.0 "	cloudy	" "	0.417
Acetic acid	1.5 cc.	clear	flocculent	0.464
Hydrochloric acid	0.3 "	cloudy	gelatinous	0.410
" "	0.5 "	cloudy	"	0.404
" "	0.75 "	milky	"	0.199

Statement of Results.—The results contained in the foregoing table show:

First, that lactic acid gives results closely agreeing with those obtained by the use of acetic acid, when about one cc. of a ten

per cent. solution of lactic acid is used, but if 0.5 cc. more or less than one cc. of lactic acid are used, the results are very low. The precipitate was flocculent and filtered readily.

Second, that a ten per cent. solution of sulphuric acid when used to the extent of 0.5 cc. for ten grams of milk gave results closely agreeing with those given by the use of acetic acid, but that when more than 0.5 cc. were used, the results became lower. The filtrate was clear, but the casein did not separate in flocculent condition, having a tendency to become gelatinous. Several filtrations were required to get a clear filtrate, and filtration was slow.

Third, that very unsatisfactory results were given by the use of hydrochloric acid, whatever the amount used. The filtrate was cloudy or milky, the precipitate gelatinous, the filtration extremely slow, and the results low.

Fourth, for the most satisfactory results, for the flocculent character of the precipitate, for rapidity of precipitation, filtration, etc., the use of acetic acid had a great advantage over the other acids tried.

(*4*) *Influence of Temperature and Time of Digestion on Precipitation of Casein.*—In making the experiments, the results of which are tabulated below, the temperature and time of digestion were made to vary, all the other conditions being kept uniform.

Temperature of digestion.	Time of digestion.	Character of filtrate.	Per cent. of nitrogen in precipitate.
30° C.	5 minutes	clear	0.448
40° "	0 "	"	0.475
40° "	1 "	"	0.479
40° "	2 "	"	0.481
40° "	3 "	"	0.471
40° "	10 "	"	0.477
40° "	20 "	"	0.484
45° "	0 "	"	0.468
45° "	2 "	"	0.476
45° "	5 "	"	0.483

The data presented in the foregoing table show:

First, that, when the precipitate was digested at 30° C. for five minutes, the results were lowest.

Second, that, when the precipitate was digested at 40° C.

without standing or with standing one, two, three, ten, or twenty minutes, the results were practically uniform. The greatest difference obtained by digesting different periods of time did not exceed 0.01 per cent. nitrogen.

Third, that, when the precipitate was digested at 45° C. for periods of time varying from a few seconds to five minutes, the results were fairly uniform, the greatest difference being 0.015 per cent. nitrogen. As compared with digestion at 40° C., digestion at 45° C. gave essentially the same results.

Fourth, it would, therefore, seem that a variation of temperature two or three degrees above or below 40° C. and variation of time of digestion after the addition of acetic acid exercises comparatively little influence upon the results. However, in practice, I think it is desirable to adhere quite closely to uniformity of temperature.

(5) *The Precipitation of Casein in Fresh and in Old Milk.*— The fact is well known that milk undergoes rapid and complex changes when left to itself at ordinary temperatures. In the course of our work, it occurred to the writer that, as a result of these changes, the casein might be so changed that the method used in determining casein in fresh milk might not be entirely applicable to milk that had undergone more or less change; or that the formation of lactic acid might make necessary the use of less acetic acid than is used in precipitating the casein of fresh milk. It was generally found that, after milk had stood at a temperature of 17° to 22° C. for twenty-four hours or more, the use of 1.5 cc. of a ten per cent. solution of acetic acid gave low results, the filtrate being decidedly turbid. In some cases the casein was almost entirely rendered soluble and passed into the filtrate. It was found that the only method of handling milk under such circumstances was to add the acetic acid to the milk, diluted with water at 40°–42° C., in small portions of a few drops at a time, stirring after each addition and continuing the additions until the liquid above the precipitate became clear or nearly so. But, even with this treatment, there was found to be more or less loss. The terms "fresh" and "old" milk are, of necessity, rather vague. Much depends upon the conditions under which milk is kept. The extent of

change rather then the actual age of the milk should form the basis of distinction. Coagulated milk gave low results.

	Age of milk.	Per cent. of nitrogen in precipitate.	Amount of loss.
Sample No. 1	Fresh	0.429	....
	7 days	0.378	0.051
Sample No. 2	Fresh	0.447	....
	1 day	0.427	0.020
	3 days	0.428	0.019
	7 days	0.428	0.019
Sample No. 3	Fresh	0.428	....
	1 day	0.410	0.018
Sample No. 4	Fresh	0.438	....
	1 day	0.415	0.023
Sample No. 5	Fresh	0.624	....
	1 day	0.617	0.007
Sample No. 6	Fresh	0.397	....
	1 day	0.397	0.000
Sample No. 7	Fresh	0.466	....
	1 day	0.445	0.021

The author has in progress an investigation relating to the detailed changes that take place in the nitrogen compounds of milk under various conditions.

Statement of Results.—First, when milk was kept at a temperature of 17° to 22° C. for twenty-four hours, the amount of nitrogen as casein was found, in most cases, to be nearly 0.02 per cent. less than in fresh milk.

Second, in case of one milk kept seven days, the amount of nitrogen in the casein was 0.051 per cent. less than in fresh milk, while, in another case, it was 0.019 per cent. less.

Third, in general, it was found necessary, in order to get results that were at all satisfactory, to use less than 1.5 cc. of dilute acetic acid to precipitate the casein in milk that had been standing long enough to undergo any marked change.

Fourth, while good results may, in exceptional cases, be secured in determining casein in milk that has undergone noticeable change without any modification of the method given for the determination of casein in fresh milk, the accuracy of such determinations must be regarded as uncertain in regular work.

(6) *The Influence of Mercuric Chloride Used as a Preservative on the Determination of Casein in Milk.*—In view of what has

just preceded, can we be certain of our results when we determine casein in milk that is not fresh? The thought suggested itself to the author that if some germicide could be added to fresh milk to prevent or retard the changes that affect the casein, then we might be able to determine the casein in milk that had stood indefinitely. In order to test the question, finely powdered mercuric chloride was used in proportion of about one part of mercuric chloride to two thousand parts of milk by weight. A sample of milk was analyzed when fresh and portions were set aside for varying periods of time, some with and some without the addition of mercuric chloride. Determinations of casein were made from time to time, using less than 1.5 cc. dilute acetic acid. The results were as follows:

Age of milk.	Per cent. of nitrogen in precipitate when no mercuric chloride was used.	Amount of loss.	Per cent. of nitrogen in precipitate when mercuric chloride was used.	Amount of loss.
Fresh	0.447	...	0.447	....
1 day	0.427	0.20	0.444	0.003
3 days	0.428	0.19	0.444	0.003

Statement of Results.—The foregoing results appear to indicate:

First, that the use of mercuric chloride in fresh milk largely prevents or retards the occurrence of those changes that effect the determination of casein.

Second, that even when mercuric chloride is used in milk, it is generally desirable to use less than 1.5 cc. of dilute acetic acid in precipitating the casein.

Third, that the use of mercuric chloride in the proportions stated did not precipitate in appreciable quantity any nitrogen compounds such as albumen.

(7) *General Summary.*—We may summarize the results of our work as follows:

First, precipitation of casein in cows' milk gives essentially the same results whether made at 40° C. without carbon dioxide or at ordinary temperatures with the aid of carbon dioxide, other conditions being uniform.

Second, between one and two cc. of a ten per cent. solution of acetic acid, generally about 1.5 cc., gave the best results.

Third, the use of lactic acid, sulphuric acid, and hydrochloric

acid gave results much less satisfactory than the use of acetic acid.

Fourth, a variation of a few degrees from 40° C. and a variation of time of digestion after the addition of acetic acid exercised comparatively little influence on the results.

Fifth, the precipitation of casein in milk that had undergone noticeable change was generally found to give lower results than in case of the same milk when fresh, even when less than 1.5 cc. of acetic acid were used. Coagulated milk always gave low results compared with fresh milk.

Sixth, the use of mercuric chloride in fresh milk, in the proportion of one part of the former to two thousand parts of milk, largely prevented or retarded the occurrence of those changes that affect the determination of casein in old milk.

Seventh, in a general way, the character of the filtrate serves as a fairly reliable guide in regard to the completeness of the precipitation of casein from milk. When the filtrate is clear or only perceptibly cloudy, the precipitation is generally complete; but, when the filtrate is decidedly turbid or milky and two or three repeated filtrations do not remove the turbidity, the precipitation will generally be found incomplete and such a determination, if carried out, will give low results.

(*8*) *Detailed Description of Method Used in Determining the Casein of Cows' Milk.*—I. In Fresh Milk: Weigh out about ten grams of milk, dilute in a beaker with about ninety cc. of water at 40°–42° C., and add at once 1.5 cc. of a solution containing ten per cent. of acetic acid by weight. Stir with a glass rod and let stand three to five minutes or longer. Then decant on filter, wash two or three times with cold water by decantation, and then transfer precipitate completely to filter. Wash once or twice on filter. The filtrate should be clear or very nearly so. If the filtrate is not clear when it first runs through, it can generally be made so by two or three repeated filtrations, after which the washing of the precipitate can be completed. The washed precipitate and filter paper are then digested as in the regular Kjeldahl method for the determination of nitrogen and the determination of nitrogen is completed as usual. To calculate the nitrogen into an equivalent amount of casein, multiply the

amount of nitrogen found by the factor 6.25. Ordinarily, for this purpose, milk can be regarded as "fresh," when it does not show marked development of lactic acid.

II. In Old Milk: When milk has undergone such change as to show marked development of lactic acid, the method above given cannot generally be relied upon to give accurate results in determining casein. So far as our results go, they indicate that we cannot with positive accuracy determine casein in such milk by any method now known, and results obtained with changed milk must be regarded as only approximate. If, however, one part of finely powdered mercuric chloride is added to two thousand parts of milk, when fresh, the changes, which would otherwise take place, are prevented or greatly retarded, so that milk treated in this manner may be used after standing some days for the determination of its casein. In such cases, the method given above for fresh milk may be followed, except that the acetic acid should be added in small portions, a few drops at a time, stirring after each addition, and continuing the addition of acetic acid until the liquid above the precipitate becomes clear or very nearly so.

NEW YORK STATE AGRICULTURAL EXPERIMENT STATION, GENEVA, N. Y.,
AUGUST, 1893.

SOME POINTS RELATING TO THE COMPOSITION OF COWS' MILK.[1]

BY L. L. VAN SLYKE, CHEMIST OF N. Y. AGR. EXP. STA.

IT is my purpose to call attention to some general results secured in our work at the New York State Agricultural Experiment Station at Geneva in the course of an extended examination of the milk of cows in that State. Our results are based upon the analysis of lots of milk aggregating over 200,000 pounds and representing the product of not less than 1,500 individual animals, and 20,000 separate milkings extending over a period of some six months.

The points to which I wish to call especial attention are the following:

1. The relation of casein to albumen in normal milk.

[1] Read before the World's Congress of Chemists, August 24, 1893.

2. The relation of fat to casein and albumen in normal milk.

3. The relation of fat to casein (excluding albumen) in normal milk.

4. The effect of removing fat from normal milk upon the relation of fat to casein.

5. The relation of fat to total solids in milk as defined by law.

(*1*) *The Relation of Casein to Albumen in Normal Milk.*—In the present state of our lack of detailed knowledge regarding the constitution and relations of the nitrogen compounds of milk, we call casein that portion of the nitrogen compounds of milk that is precipitated by rennet, dilute acids, and certain salts. The remaining portion of the nitrogen compounds of milk we call albumen, though we know that there are at least two different compounds in this portion. The casein was determined by precipitation with dilute acetic acid and the nitrogen in the precipitate estimated by the regular Kjeldahl method, the nitrogen multiplied by 6.25 gave casein. The details of the method are contained in a paper presented elsewhere by me. The amount of casein subtracted from the total amount of nitrogen compounds in the milk gave the albumen by difference.

The point to which I wish to direct attention in this connection is this: Do casein and albumen in the normal milk of cows bear a definite or a variable relation to each other? So far as I have been able to ascertain, the only positive statement on this point has been made by Blyth (Foods: Composition and Analysis 2. ed., p. 208,) and he says: "The amount of albumen in milk is really fairly constant, and averages 0.7 per cent. In healthy cows it is a very constant quantity, the chief deviation occurring directly after calving, when the amount may rise as high as three per cent., but this is always accompanied by a corresponding rise in the casein. According to the author's experience, the albumen preserves a very constant relation to the casein, the quantity of the latter being five times that of the albumen; so that if either the amount of casein or albumen is known, the one may be calculated from the other with great accuracy." The foregoing statement has been quite generally accepted as authoritative. It is to be regretted that Blyth does not state the extent of the work upon which he bases his

general conclusion and also the source and character of the milk examined by him.

The results secured in our work with the mixed milk of herds of cows and with individual cows of different breeds do not agree with the statement of Blyth. In outline our results were as follows:

(1) The amount of casein varied from 1.93 to 3 per cent., and averaged 2.48 per cent.

(2) The amount of albumen varied from 0.55 to 0.86 per cent. and averaged 0.66 per cent.

(3) For each pound of albumen in the milk the casein varied from 2.6 to 4.9 pounds, the average being 3.76 pounds of casein for one pound of albumen.

All our work goes to show that the relation of casein to albumen in cows' milk is a variable one, and that very rarely does milk contain five parts of casein for one of albumen and not often does the ratio go above four and one-half to one and seldom goes below three to one, while the average is somewhat under four parts of casein to one of albumen.

(2) *The Relation of Fat to Casein and Albumen in Normal Milk.*—The average composition of milk as given in many of our best authorities generally exaggerates the proportion of casein and albumen. Whether this has come from faulty methods of analysis, or the use of too large a factor in converting nitrogen into casein, or from peculiar kinds of cows, it is difficult to say. In nearly all of the older works we find the amount of casein and albumen given in excess of the fat, and in more recent statements the proportion is large. It may be that our cows in New York State do not give milk like cows in other countries, but the fact has impressed me very strongly that our results show that the relation of casein and albumen to fat in milk is not as great as reported elsewhere.

Giving the general average of our results, we have found the fat to be 3.70 per cent., the casein and albumen, 3.14 per cent., or for each pound of casein and albumen there was on an average nearly 1.20 pounds of fat. The lowest ratio found was 1.07 of fat and the highest 1.33 of fat to 1 of casein and albumen. In working with the mixed normal milk of herds,

we have never found a single instance in which the milk contained more casein and albumen than fat, and, moreover, we have not found a single instance in which the milk contained as much casein and albumen as fat. In working with the milk of individual cows of seven different breeds we have not yet found a single instance where any individual (in normal health) of any breed gave milk for any considerable period of time that contained as much casein and albumen as fat.

(3) *The Relation of Fat to Casein (Excluding Albumen) in Normal Milk of Cows.*—So far as I have been able to ascertain, there are on record outside of the data furnished by the Geneva (New York) Experiment Station no determinations of casein in cows' milk embracing large amounts of milk during an extended period of time; and hence the relation of casein to fat in cows' milk has received little or no attention until recently. In working with the mixed milk of herds of cows for a period of six months we obtained the following results:

(1) In normal milk which contained fat varying from 3 to 4.5 per cent., the casein varied from 1.93 to 3 per cent. The fat averaged 3.70 per cent., and the casein 2.48 per cent.

(2) In no case did normal milk contain less than 1.35 pounds of fat for one pound of casein, or more than 1.74 pounds of fat for one pound of casein, while the average of all was 1.5 pounds of fat for one pound of casein. Over seventy-five per cent. of the individual results were within one-tenth of the average.

(3) In examining the normal milk of individuals of seven different breeds of cows during the past year, we have never found for any extended period that there was less than 1.3 pounds of fat for one pound of casein.

(4) *The Effect of Removing Fat from Normal Milk upon the Relation of Fat to Casein.*—When fat is removed from milk, the milk loses little else in the way of solids. The casein remains essentially undiminished in quantity. Hence, the greater the amount of fat removed the more casein there will be in proportion to the fat left. In numerous experiments made to ascertain the effect of skimming milk upon the relation of fat to casein, it was found that in no case did skim-milk contain more than 1.35 pounds of fat for one pound of casein and this was

in case of a milk which had less than ten per cent. of its fat removed. As a rule, taking average normal milk as found in New York State, we have found that if as much as twenty per cent. of the fat in the milk is removed the resulting skim-milk will contain less than 1.3 pounds of fat for one pound of casein. Now, considering the fact that we have not found any normal milk to contain less than 1.30 pounds of fat for one pound of casein, while the average is 1.50 pounds of fat for one of casein, it would appear that we might make a practical use of this relation of fat to casein for the detection of skimmed milk. Our work makes it appear that if milk contains less than 1.30 pounds of fat for one pound of casein, it has been skimmed. I feel justified in saying that this standard would be found to give true results ten times where the present crude legal standard used in New York State and elsewhere would be found to give correct results once in a case of skim-milk. And this brings me to my next and last topic.

(5) *The Relation of Fat to Total Solids in Normal Milk as Defined by Law.*—The present legal standard of normal milk in New York and several other states requires that normal milk shall contain twelve per cent. of solids, of which three per cent. shall be fat. I am not entirely certain as to where this so-called minimum standard originated, or upon what work done in New York State its adoption there was based; but I have this to say of normal milk as found at present in New York, that in an examination of a large number of samples of mixed milk of herds representing nearly half a million pounds of milk and the product of several thousands of different cows I have not yet found a single instance in which such milk contained at the same time three per cent. of fat and as much as twelve per cent. of solids. Moreover, in examining a large number of samples of milk from individual cows of many different breeds, I have not found twelve per cent. of solids in milk containing three per cent. of fat, unless the animal was in an abnormal physical condition. It is not difficult to see why normal milk containing three per cent. of fat should not contain twelve per cent. of total solids. Normal milk containing three per cent. of fat should contain about 5.50 per cent. of sugar and ash or 8.50

per cent. solids without casein and albumen. If such milk contains twelve per cent. of total solids, then there must be 3.50 per cent. of casein and albumen, that is 3.50 per cent. of casein and albumen for three per cent. of fat, a relation of these compounds, which, as I have previously stated, I have not yet found in normal milk. Only in skimmed milk containing three per cent. of fat should we expect to find as much as twelve per cent. of solids.

General Summary.—We may briefly summarize our statements as follows:

(1) The relation of casein to albumen in normal milk is more or less a variable, and not a definite one.

(2) The amount of fat in normal milk is very rarely less than the amount of casein and albumen. On an average there are 1.20 pounds of fat for one pound of casein and albumen.

(3) Average milk contains about 1.50 pounds of fat for one pound of casein (excluding albumen).

(4) The removal of fat from milk reduces the ratio of fat to casein in the resulting skim-milk. When milk contains less than 1.30 pounds of fat for one pound of casein the milk has in all probability been skimmed.

(5) The legal minimum standard, which requires milk containing three per cent. of fat to contain twelve per cent. of total solids, does not agree with the composition of normal milk as found in New York State, since normal milk that contains three per cent. of fat will contain considerably less than twelve per cent. of total solids. The legal requirement would be met with only in skimmed milk.

IMPROVED UREOMETER.

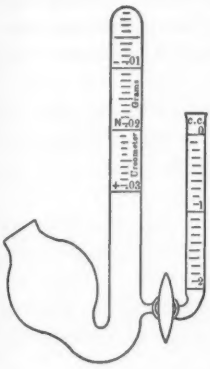
By Professor J. I. D. Hinds.

Received October 5, 1893.

IN using the ureometer designed by Prof. Doremus I have found two sources of considerable error. In the first place, it is impossible to run in from the pipette exactly one centimeter of the urine. In the second place, some bubbles of nitrogen almost invariably escape at the bulb of the instrument.

To remove these sources of error, I have devised the appara-

tus shown in the accompanying figure. A tube graduated to tenths of cc. is attached on the side opposite the bulb, and the two tubes are connected by a stopcock. The instrument is filled with the test liquid in the usual way and then the small tube is filled with the urine. Exactly one cc. is allowed to run in through the stopcock, and then the nitrogen is measured in the larger tube. The instrument gives as great accuracy as can be attained with the small quantities dealt with. The hole in the stopcock should be filled with the urine. This can be done by running in a drop or two of urine before filling with the test liquid.



The instrument is conveniently held with the left hand while the stopcock is being operated with the right.

CUMBERLAND UNIVERSITY,
LEBANON, TENNESSEE.

CHEMICAL CONSIDERATIONS ON THE POTTERY INDUSTRIES OF THE UNITED STATES.

BY KARL LANGENBECK.

Received Nov. 16, 1893.

PART I.

OUR pottery industries have developed so purely on an empirical basis, that very little of a chemico-technical character has found its way into English literature concerning them.

Our potters are, almost without exception, innocent of chemical knowledge, and American chemists have had little opportunity of working in their manufactories, or have not felt at liberty to publish their experience in such lines of work.

As, however, the diligence of our many geological surveys causes many thousands of clays to be annually collected, described, and analyzed, it is unfortunate that such extensive

work brings industrially no fruit, because the chemists so employed seem to have no knowledge of the potter's needs and present data that even to the pottery expert are valueless, stopping short, as they do, of the point at which their analyses would prove of use.

It is with the hope that this diligent and extensive effort of the chemists of our geological surveys may be directed into serviceable channels, that a description of the main branches of our American pottery industry will be attempted.

The most important domestic products of our markets, are fire clay goods, terra cotta, red ware, yellow ware, stone ware, C. C. (*i. e.*, cream colored), and white granite ware. The manufacture of bone china and to a limited extent of feldspar porcelain have also been begun, but are not as yet, industrially as important as the former.

Concerning the first two classes, fire clay products and terra cotta, it is not the purpose of the writer to consider them in the course of this article; not because they lack interest from the point of view of the chemist, but because the manufacturer of these wares stands in no such need of the chemist, as the manufacturer of glazed wares, and considerations applying to the examination of the raw materials of the latter, apply equally to those of the former.

Red Ware.—The simplest and cheapest of glazed pottery is called from its color, "red ware." It is ordinarily formed from the same materials used for making red brick; alluvial mud found in the river valleys and weathered ferruginous shales. It is important that the material contain but little lime, which if present in any considerable amount, destroys the bright red color imparted by the oxide of iron, giving unsightly ware.

At a heat sufficient to melt a wire of pure silver to a bead, the clay should bake so hard, that it can barely be cut with a knife. The specimen baked at that heat should adhere, when touched to the tongue and be of a bright red color.

The clay must be of such composition, that with the hardness attained at the given temperature (from the melting point of silver to not exceeding that of an alloy of seventy-five per cent. silver, twenty-five per cent. gold), it will have practically the

same co-efficient of expansion, and hence bear without fracture, a glass fusible at that heat.

A glass or "glaze" of this character would be one having a chemical formula lying between 1. PbO 0.1 Al_2O_3 1. SiO_2 and 1.0 PbO 0.15 Al_2O_3 1.5 SiO_2 made by grinding together

129.7 parts white lead,

13.0 to 19.5 parts china clay,

24. to 21. parts quartz.

In order to absolutely resist the action of acids on cooking utensils of "red ware," it would be desirable to use more acid glazes, but such is not the practice in this industry; although there is a practice that should be absolutely condemned and against which chemists should throw their influence, namely, that of using litharge or galena alone as the glazing substance and depending on its taking up sufficient alumina and silica from the body of the ware, during fire, to form the glass. A "glaze" so formed is certain to be basic on the surface, and is sure to be attacked by the weakest acids used in cookery.

The red ware potter has no china clay at his disposal, and usually makes his glaze by grinding the lead preparation with a loamy sand.

The glaze then has frequently some such composition as this—

$$1.0\ PbO \begin{cases} 0.09\ Al_2O_3 \\ 0.03\ Fe_2O_3 \end{cases} 1.4\ SiO_2$$

(taken from practice). This glaze would be of a yellowish color, which is not objectionable.

The co-efficient of expansion of the clay depends on the amount and fineness of the uncombined silica and feldspathic detritus it contains, which constituents, are in the analysis, determined by the "rational analysis" of Seger and Aaron.

A practical "red ware" clay, burning at the indicated temperature to the required hardness and color, and bearing the glaze without suffering fracture ("shivering") or the glaze itself cracking ("crazing"), being of sufficient plasticity and having from the clay to the baked condition a linear shrinkage of one-sixteenth, is a weathered shale of the following analysis:

TOTAL ANALYSIS.

	Per cent.	Insol. in H_2SO_4 and Na_2CO_3.
Silica	74.75	57.20
Alumina	12.55	0.62
Ferric Oxide	5.28	0.70
Lime	1.28	0.77
Magnesia	0.85	0.00
Alkalies	2.27	1.80
Combined Water	3.23	
	100.21	61.09

RATIONAL ANALYSIS.

	Per cent.
"Clay Substance"	39.12
Quartz	52.54
"Feldspathic detritus"	8.55

PERCENTAGE COMPOSITION OF THE "CLAY SUBSTANCE."

	Per cent.
Silica	44.86
Alumina	30.50
Ferric Oxide	11.71
Lime	1.30
Magnesia	2.17
Alkalies	1.20
Combined Water	8.26
	100.00

The following, a highly plastic red colored clay, proved unsuitable. It was too plastic and would twist and crack in the fire; it burned to a dark brownish red, instead of a light bright color, shrinking one-eighth linear measure in the fire. It contains insufficient uncombined silica to bear a glaze suited to the red ware fire, without the latter's "crazing."

TOTAL ANALYSIS.

	Per cent.	Insol. in H_2SO_4 and Na_2CO_3.
Silica	61.93	28.98
Alumina	19.87	0.53
Ferric Oxide	7.83	1.57
Lime	1.61	0.16
Magnesia	0.77	0.08
Alkalies	2.38	1.08
Combined Water	5.91	
	100.30	32.40

RATIONAL ANALYSIS.

	Per cent.
Clay Substance	67.90
Quartz	21.57
Feldspathic detritus	10.83

PERCENTAGE COMPOSITION OF THE "CLAY SUBSTANCE."

	Per cent.
Silica	48.53
Alumina	28.48
Ferric Oxide	9.22
Lime	2.14
Magnesia	1.02
Alkalies	1.92
Combined Water	8.70

The wares manufactured in this industry are flower-pots and other unglazed terra-cotta articles; of glazed articles, brown door-knobs, milk crocks, bean pots, and other cooking vessels, pots for corroding white lead, jardiniers, umbrella-stands, spittoons, etc., which latter ornamental pieces are often decorated on the outer unglazed surface with oil colors.

The chemist in order to determine the suitableness or unsuitableness of a clay for this industry should make a "rational analysis" of the same. He should determine by kneading, in a general way, the plasticity of the material and the coarseness of the admixed quartz.

Cakes several inches square and about $\frac{3}{16}$ inches thick, should be formed and dried and placed in a muffle with a wire of pure silver; on one or two of the cakes such a glaze-mixture as described before should be painted to the depth of about $\frac{1}{32}$ inch. The muffle is then fired with a gradually increasing heat until in the course of three hours, the silver wire melts, when firing is discontinued.

It goes without saying that an oxidizing fire must be maintained throughout the burning, in order to insure a bright red color of the clay by complete oxidation of its iron and to prevent a reduction of the lead of the glaze.

When cold the pieces are withdrawn and the color and hardness of the unglazed ("biscuit") pieces and the character of the glazed sherds, and whether in the course of some weeks the latter bear the glaze without defect, are noted.

ZANESVILLE, O., Nov. 15, '93.

CONTRIBUTIONS TO THE STUDY OF OIL-CAKES USED IN FEEDING.[1]

By C. V. Garola.

Translated and Abstracted by Dr. G. L. Spencer, Washington, D. C.

THESE contributions consist of a series of studies including all the oil-cakes used in the feeding of domestic animals. For the purposes of the Congress the article on cotton-seed oil-cake has been selected for presentation, owing to the general importance of this product.

Cotton-Seed Oil-Cake.—Cotton-seed oil-cake is manufactured from the seed of the cotton plant. It is green when fresh, but becomes brown and dark on standing. It usually contains a variable quantity of cotton-seed hulls, dark débris, seed coats, etc. The oil-cakes from cotton-seed may be divided into three classes:

First, those which contain a considerable quantity of filaments of cotton and which are only suitable for use as fertilizers.

Second, those from Egypt and the Levant where the manufacturers clean the seed very thoroughly from the cotton fiber.

Third, oil-cakes manufactured from decorticated seed in America. In these last the hulls are removed from the seeds, hence these cakes are richer and in a more favorable condition for feeding young animals. We have analyzed two of the last named class. These analyses are shown in parallel columns with the results obtained by Décugis and Woelcker:

	Garola.		Décugis.		Woelcker.
	Cotton-seed from Alexandria.	Decorticated cotton-seed.	Cotton-seed oil-cake from Alexandria.	Cotton-seed oil-cake containing some fiber.	Decorticated cotton-seed.
Water	12.44	7.78	9.3	9.15	9.28
Nitrogenous matter	28.00	47.81	24.1	20.2	41.12
Fat	5.86	12.87	6.1	5.3	16.05
Non-nitrogenous extract matter	40.64	20.84	54.5	58.6	25.5
Cellulose	8.14	3.80			
Ash	4.92	6.90	5.96	6.4	8.05
Nitrogen	4.48	7.65	3.86	3.4	6.58
Phosphoric acid	1.85	3.33	1.62	1.99	6.58
Potash	0.98	0.98	1.62	1.99	6.58

[1] Read before the World's Congress of Chemists, August 24, 1893.

The cotton-seed oil-cake from Alexandria is very much esteemed for the feeding of milch cows. It is very advantageous notwithstanding the fact that its cost is a little high. At the time of writing it costs ten francs, fifty centimes, per 100 kilos, f. o. b. cars at Marseilles. We might cite several dairies, where milk is sold, situated in the suburbs of Nancy, where these oil-cakes have given excellent satisfaction.

The older cattle have considerable power for the digestion of cellulose. In my work, "Alimentation des Animaux de la Ferme," published by G. Masson in 1887, I have applied the results obtained in the digestion of woody fibers by cattle as given in the works of Haubner, Sussdorf, and Stoeckhardt:

	Per cent.
(1) Paper pulp, very fine	72 to 80
(2) Grass, cut at the time of flowering	60 to 70
(3) Paper pulp from straw and wood sawdust	40 to 50
(4) Spruce sawdust	30 to 40

From these experiments, it appears that the filaments of cotton and the fragments of the seed coating do not present any serious inconvenience to full grown cattle. Such oil-cakes, however, should not be permitted to be fed to young cattle. M. Fagot, a distinguished chemist of Ardennes, has reported several fatal accidents to calves, which have followed the feeding of cotton-seed oil-cake from Egypt. One can easily conceive that the stomachs of the young cattle could not easily dissolve the filaments of cotton and fragments of the hard horny seed coat. As these indigestible particles encumber the third stomach and press upon the rennet, these parts are consequently paralyzed in their action.

Oil-cake from decorticated cotton-seed, which has been sold in the form of a coarse meal at a price of seventeen francs per 100 kilograms, seems perfectly suited for the nourishment of young cattle. I have recommended formerly a mixture of equal parts of wheat bran and linseed meal for the first feeding of lambs. This seems still better suited to the feeding of full grown animals for their fattening and the production of milk. Woelcker in 1888 made a decisive experiment upon the comparative nutritive value of oil-cake from decorticated cotton-seed mixed with its weight of corn flour and oil-cake from linseed in

the fattening of cattle. These beef cattle were divided into two lots and weighed at the beginning of the experiment as follows:

	Kilograms.
Lot No. 1	1,482
Lot No. 2	1,437

Each of these lots received the same quantity of chopped beet roots, hay, and straw. As a nutritive supplement he fed to the first lot cotton-seed oil-cake and corn flour, while to the second lot he fed linseed oil-cake. In the six months during which the experiment lasted the first lot consumed:

	Kilograms.
Beet roots	1,713
Hay	457
Straw	234
Corn flour	660
Cotton-seed oil-cake (decorticated)	660

These oil-cakes were fed in a ration of 3.6 kilograms per head per day.

The second lot of cattle consumed during the same time:

	Kilograms.
Beet roots	1,714
Hay	457
Straw	234
Linseed oil-cake	1,320

The ration per day per head was 6.8 kilograms. While the increase in the weight of the cattle fed on cotton-seed oil-cake (decorticated) with the addition of corn meal was upwards of 222.7 kilograms, it was only 188.9 kilograms with the linseed oil-cake. Each beef had gained in the first case 1.18 kilos, and in the second only 0.96 kilos.

The ration with cotton-seed oil-cake was, however, more economic. At the present prices, the cotton-seed oil-cake costs nineteen francs and the broken corn sixteen francs at the farm; the concentrated foods distributed in the first lot costs as follows:

Cotton-seed oil-cake:	660 kilograms	× 0.19 =	125.40 fr.
Corn:	660 "	× 0.16 =	105.60 fr.
Total			231 fr.

The linseed oil-cake costs, on the other hand, 19.5 francs per 100 kilograms, or in all for the second lot 257.40 francs.

From this we see that in one case there was a gain in live weight of forty kilograms with the cotton-seed and at the same time a lower expense of 26.40 francs.

The mixture containing the cotton-seed oil-cake (decorticated) and the corn is thus shown to be largely superior to the pure linseed, and, as this latter according to the unanimous judgment of practical men is one of the best oil-cakes, it is incontestable that the cotton-seed oil-cake merits especial esteem for fattening cattle.

I will also point out an experiment of Mr. Eloire (Progrès Agricole du 15 Novembre, 1891), where the same two cows were submitted during two successive periods to a feeding experiment with different foods. During the first period the cows each received:

	Kilograms.
Straw	6
Hay	6
Cotton-seed oil-cake	3
Bran	0.75

and they gave on an average 12.5 liters of milk containing thirty-seven grams of butter per 1,000, hence each cow furnished 462.05 grams of butter. In the second period each cow consumed the following:

	Kilograms.
Straw	6
Hay	6
Linseed oil-cake	1.5
Bran	0.75

The average yield of milk in this case was 11.1 liters of a richness in butter of 33.4 grams. The butter produced per day by each cow was 370.07 grams. One may see that the cotton-seed oil-cake acted in a very marked degree upon the secretion of milk and the production of butter. As was the case with sesame and coprah especially, it augments the quantity of both the milk and the butter. Thus a favorable comparison is shown between cotton-seed oil-cake and that from linseed as given in the experiments of Woelcker and Eloire.

We can not finish this study of cotton-seed oil-cake without calling attention to the excellent results obtained by Mr. Vitalis

in the feeding of milk ewes at Larzac with cotton-seed from Alexandria:

"The experiments which I undertook lasted three consecutive years," says this agriculturist, "upon my flock at Larzac and were conclusive in a high degree. At the beginning of the experiment, in order to take account of the efficacy of the cotton-seed oil-cake, I selected ten milch ewes and gave to each one a daily ration of 250 grams of the broken oil-cake in two meals, that is, 125 grams in the morning and the same amount in the evening. These sheep, which before the trial had received a ration of one kilogram of second crop hay per day, now only received 300 grams. The increase in the yield of milk was sensible even the first days. The ten animals gave a quantity of milk equal to that produced by fourteen ewes feeding upon the ordinary ration of second crop hay. After such manifestly advantageous results I wished to ascertain if possible whether the reverse would be the case. I separated ten other ewes to which I gave the ration of cotton-seed oil-cake and second crop hay that I had given the first lot, and the first lot I placed upon the ordinary food. The milk gradually increased with the new lot of ewes and decreased to the usual quantity with those submitted to the first experiment."

Mr. Vitalis adds that by the use of cotton-seed oil-cake the price of food per ration has been reduced from ten centimes to six centimes.

He has determined in addition that by the use of the oil-cake the wool, washed in boiling water and soda—per cent. raw wool—was increased sensibly. Before the use of the oil-cake the raw wool yielded thirty-six per cent. at the maximum; afterwards, on the contrary, it yielded 37.4 in 1878, 38 in 1879, and 39.8 in 1880. This progression is quite significant.

The results which we have given show what advantage agriculturists may obtain from the use of cotton-seed oil-cake. It remains for us now to describe how this should be fed.

Cotton-seed oil-cake when mixed with boiling water has a disagreeable taste. On this account it should not be distributed mixed with water. It is admitted that the oil-cake should be broken up into rather fine particles without necessarily reducing

it to a powder. It is the hard particles which the ruminating animals object to eating, since they cause diarrhea on account of their indigestibility. This difficulty may be obviated by care in breaking up the oil-cake a week in advance in such a way that it can be softened by absorbing moisture from the atmosphere without molding. One may avoid molding by placing the cake in a well-ventilated granary.

CONCERNING THE METHOD OF DETERMINING THE MELTING POINT OF BUTTER.[1]

By Adolf Mayer.

Translated by W. H. Krug.

IN my work on the relation between the constitution of butter fat and the feeding of the milch cows I have been considerably engaged with the determination of melting points, and found it important to make some experiments for the special purpose of determining the best method of carrying out these determinations. This work brought me to the following results, of which each will be accompanied by the experimental figures relating thereto.

1. Narrow tubes give lower melting and higher congealing points than wide tubes, and in this manner temperatures which are nearer together and thus assume an apparently greater accuracy as far as they are related to each other.

Experiments were carried on (1) with a certain butter fat, (2) with a fat of known uniform composition (caprylic acid), (3) with a known mixture of two fats (two parts oleic acid and one part palmitic acid).

The results were:

(1) WITH BUTTER.

	In tube of 16mm. internal diam.	In tube of 7mm. internal diam.
Melting point	40.4°	39.9°
After rapid cooling to low temperature	38.9°	38.5°
After slowly warming	36.8°	36.4°

Therefore in every case ceteris paribus about 1-2°C. lower in the narrow tubes.

[1]Read before the World's Congress of Chemists, Aug. 21, 1893.

(2) WITH CAPRYLIC ACID.

	In tube of 16mm. internal diam.	In tube of 7mm. internal diam.
Melting point	30.3°	27.3°
After rapid cooling to low temperature	30.2°	26.8°
After slowly warming	29.8°	26.4°

The result thus being analogous and at the same time much more manifest with a uniformly constituted fat. The difference amounts easily to 3°C.

(3) MIXTURE OF OLEIC AND PALMITIC ACIDS.

	In tube of 16mm. internal diam.	In tube of 7mm. internal diam.
Melting point	38.4°	38.0°
After rapid cooling to low temperature	37.8°	37.3°
After slowly warming	37.0°	36.4°

The result being in every respect similar to butter, which, as we know, is a mixture of fats.

The explanation of the phenomenon observed is apparent. The melting point when determined in a narrow tube (not so narrow that capillary attraction can exert any material influence) is always found lower because these tubes are more easily penetrated by the temperature of the surrounding liquid which is measured with a thermometer. This action is most manifest with a fat of uniform constitution as here the amount which melts at the same time is very great, causing the immediate absorption of considerable latent heat and permitting the rapid attraction of heat from the surrounding liquid to exert considerable influence. In these experiments we must always keep the fact in mind that in melting point determinations that temperature is noted at which the last particles of fat disappear, so also in the determination of congealing points that temperature at which the first solid particles appear, as it is impossible to obtain as accurate a figure for the first softening or the last stage of solidification. The primary softening and final melting are, however, near together in a uniform fat, while in mixtures where complicated phenomena of solution and supersaturation are important factors this is never the case.

One experiment will suffice to illustrate the higher congealing points obtained in narrow tubes.

MIXTURE OF OLEIC AND PALMITIC ACIDS.

	In tube of 16mm. internal diam.	In tube of 7mm. internal diam.
Congealing point	32.3°	33.1°
After rapid cooling to low temperature	33.1°	33.4°

The influence is therefore approximately of the same extent as with melting points. This is naturally exactly explained as before.

2. Lower melting points are always obtained when the fat is warmed slowly than when it is warmed rapidly. The former are without doubt the more nearly correct, as the melting fat has more opportunity to adapt itself and its properties to the conditions opposed by the new temperature. As proof for this statement the figures recorded above may be applied, though they must be arranged somewhat differently. The influence in this case is especially slight for a uniform fat (only a part of a degree) and large for the artificial mixture and the butter fat (several degrees). By a slow warming I mean a rise of 1° in five minutes, while in the other experiments the temperature was raised 1° every two and one-third minutes.

An explanation of this action can be found in the fact that the melting of a chemical compound is a much simpler phenomenon than the melting of a mixture where in reality at the final temperature a still solid body dissolves in the liquefied portion. Solution takes place, however, only on the surface, and thus more slowly, while liquefaction is instantaneous throughout the whole mass. The former process would, therefore, be benefitted by a longer period of time—an assumption which is verified by the results.

3. To obtain good melting points one must be careful that the previous congelation was complete, for which in butter-like substances a cooling to about 10° below the actual congealing point is absolutely necessary. This is especially important in repeated determinations with the same sample when heating and cooling follow each other rapidly.

For the experimental proof of this statement the figures given above are, however, of no value, although I there speak of rapid and extended cooling. The differences there observed disappear when the heating is conducted slowly and carefully, at least

when the melting points are determined as they were in these experiments. If they are determined, however, as I have permitted them to be in other experiments, by the sinking of a drop of water in the sufficiently softened fat, it is self-evident that then the half-soft condition caused by a preliminary melting is not without influence upon the result. This, however, is a circumstance which can not be easily avoided. I have, nevertheless, when making melting point determinations of butters by this method, obtained fairly concordant or at least parallel results with those obtained when I took the mean of the melting and congealing points determined in the manner described.

The experiments were made by Mr. F. J. von Pesch, Assistant at the Station.

ROYAL EXPERIMENT STATION,
Wageningen, July 10, 1893.

NEW BOOKS.

EXPERIMENTS ON AIR. PAPERS BY THE HON. HENRY CAVENDISH, F.R.S. 1784–1785. Alembic Club Reprints, No. 3. 12mo. Cloth. 52 pp. Wm. F. Clay.

To read Cavendish's papers is inspiring. He did so much with so little. Accuracy in experiment and insight into the causes of phenomena characterize all his work, notwithstanding the phlogiston fog in which he moved. This booklet contains two of his papers both taken from the Philosophical Transactions; the first, read Jan. 5, 1784, relates to his discovery of the composition of water; the second, read June 2, 1785, tells how he discovered the composition of nitric acid by uniting the oxygen and nitrogen of the air by the electric spark. To those who do not have access to the originals this series of reprints will be invaluable. E. H.